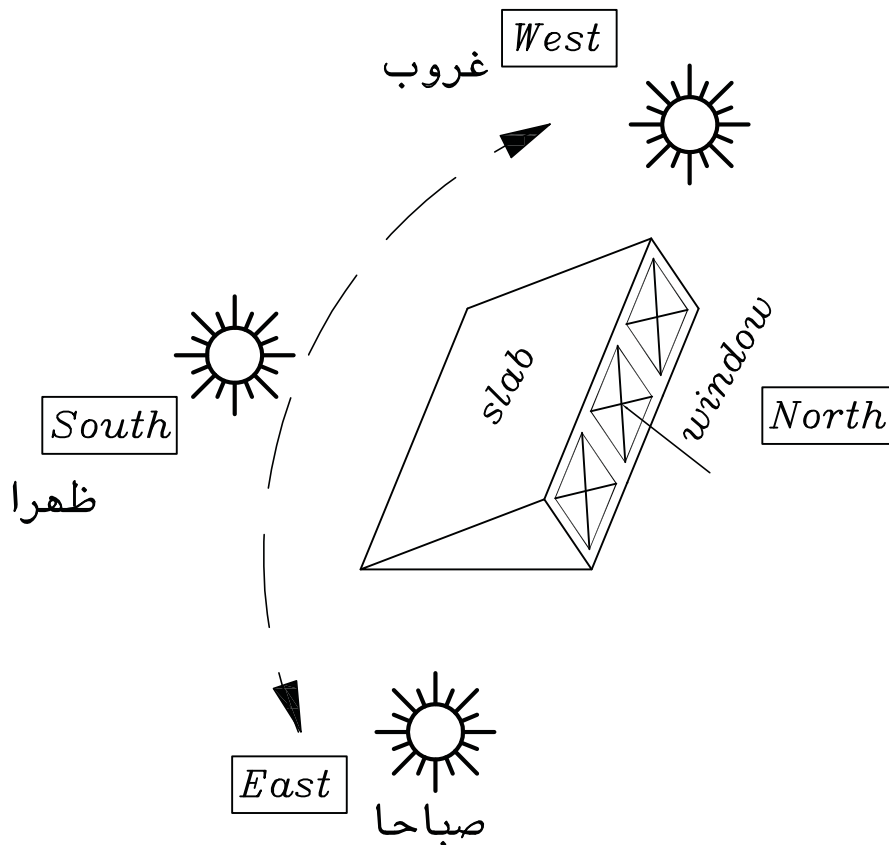# Saw Tooth Structures
(North Light Structures)

منشأت يشترط فيها عدم تعرضها لضوء الشمس المباشر وذلك نظرا لان الضوء المباشر يمكن أن يسبب أضرار داخل المنشأ مثل مصانع المنسوجات و البويات والمواد الملتهبة.

من الشكل الموضح نجد أن الشباك لا يرى الشمس مطلقا فى اى فترة من فترات النهار وبالتالى تكون الاضاءة غير مباشرة كذلك تكون النوافذ فى اتجاه التهوية (الاتجاه البحرى) .
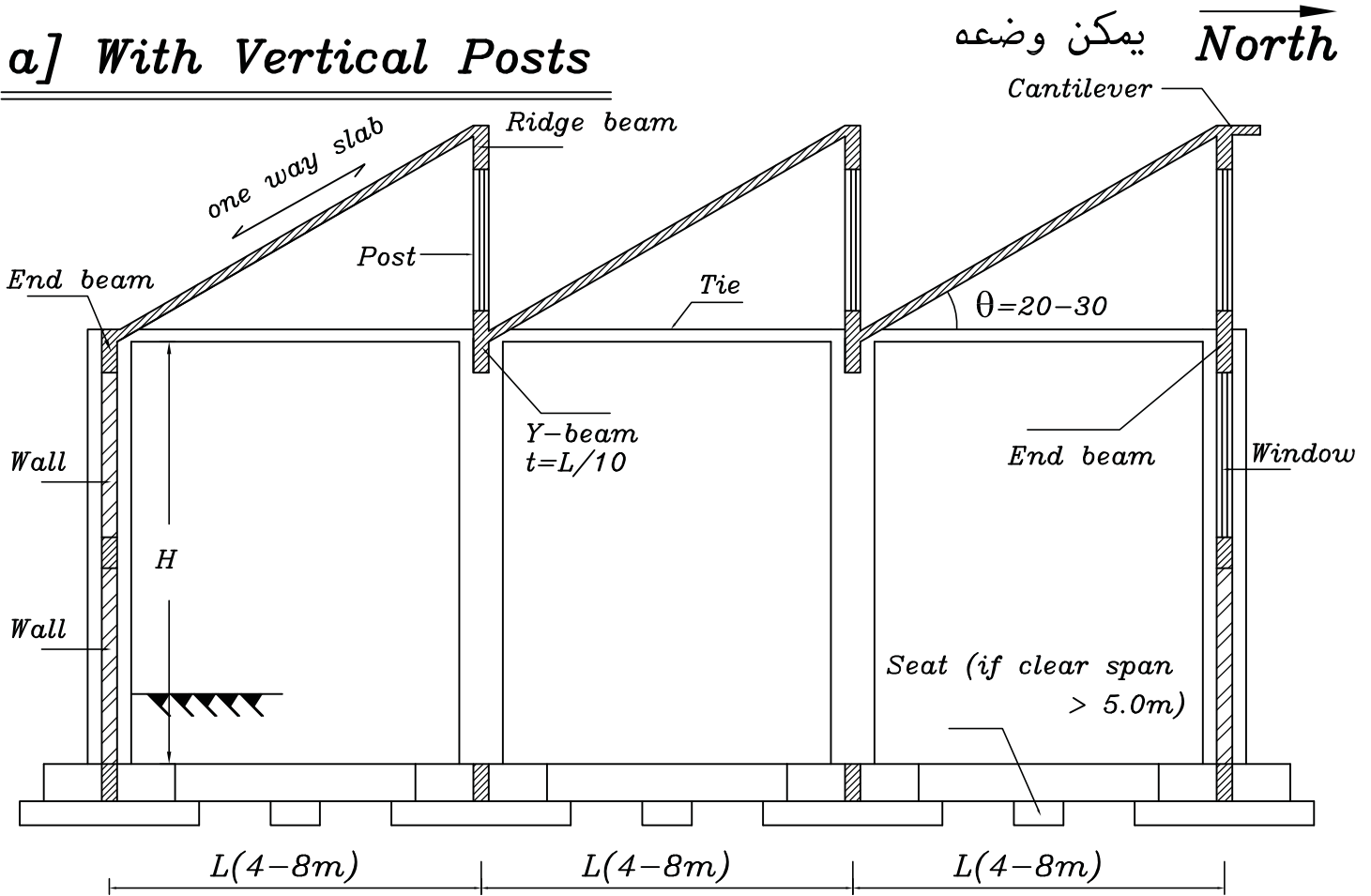
Types of Saw Tooth Structares

1] Slab Type   4 ⟶ 8m

2] Girder Type 8 ⟶ 12m

3] Saw tooth Supported on a system [frame, Polygon, Arch girder,Truss]

By Eng. Ezz El-Din Mostafa & Eng. Yasser M. Samir

1]Saw Tooth Slab Type

a] With Vertical Posts

يمكن وضعه $\overrightarrow{\text{North}}$

Cantilever

Ridge beam

one way slab

Post

End beam

Tie

θ=20−30

Wall

Y−beam
t=L/10

End beam

Window

Wall

H

Seat (if clear span
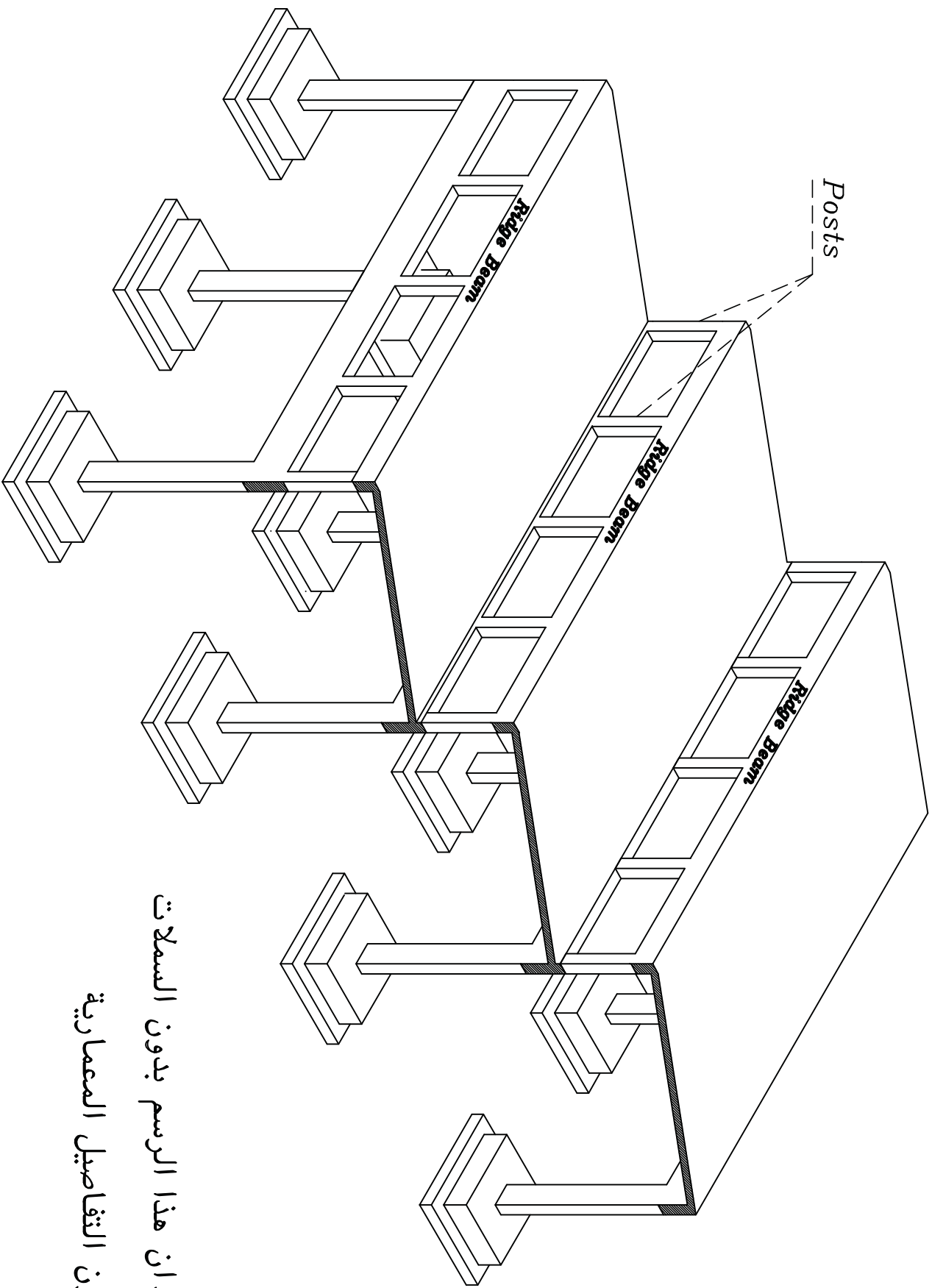> 5.0m)

L(4−8m)   L(4−8m)   L(4−8m)

Saw Tooth Slab Type is used for Span (4−8m)

Concrete Dimensions

−One way Solid Slab   (4 ⟹ 5m)

−One way H.B. Slab   (5 ⟹ 8m)

−Tie (300*300)

−Post (250*250)

−Distance betwen posts (2 ⟹ 3m)

− $t(col)=\dfrac{H}{12}$
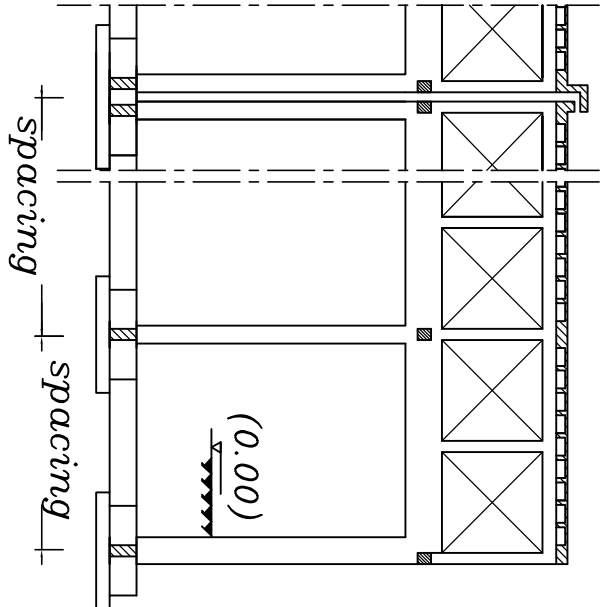
ـ ملحوظة
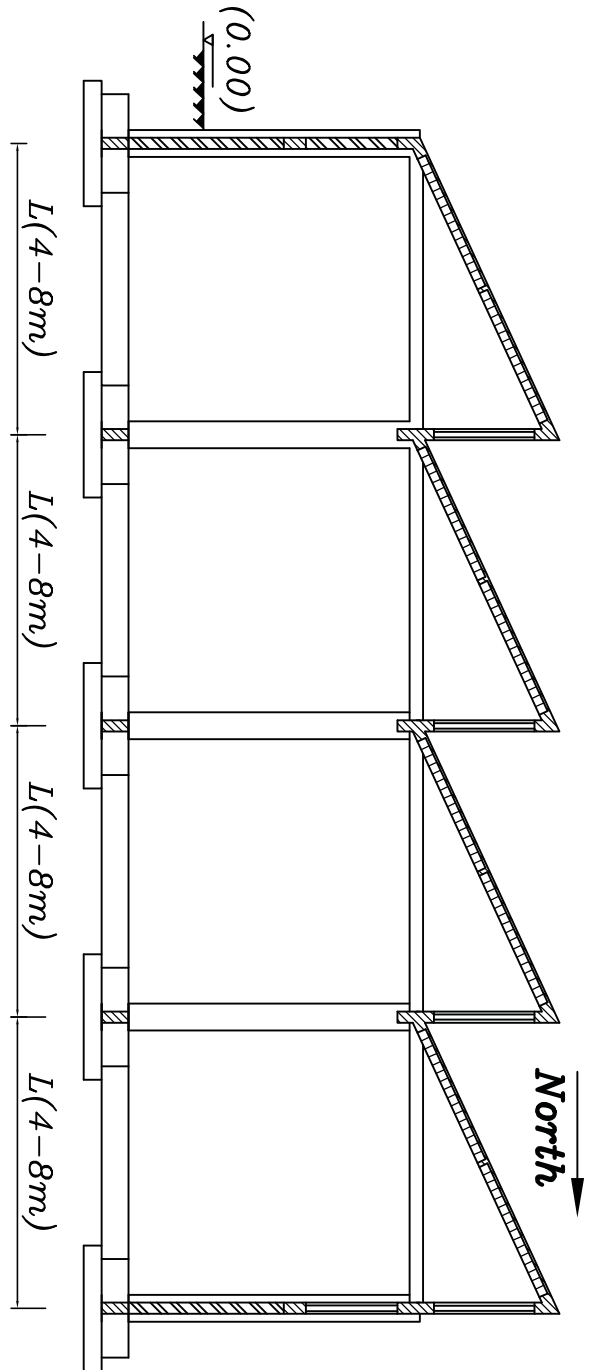
يتم وضع Tie للتربيط بين الاعمدة فقط.

و يمكن عدم وضعه

System الـ تنفيذ عن مثال حوالي

Posts

Ridge Beam

Ridge Beam

Ridge Beam

نلاحظ من الشكل أن الريم يحمل على عدة أعمده

و أن التنفيذ العملي لهذا الريم هو كالأتي

KEY PLAN
1:200 ─► 1:400

Plan

spacing

spacing

Side view

spacing | spacing

(0.00)

Elevation

(0.00)

L(4-8m) | L(4-8m) | L(4-8m) | L(4-8m)

North ─►

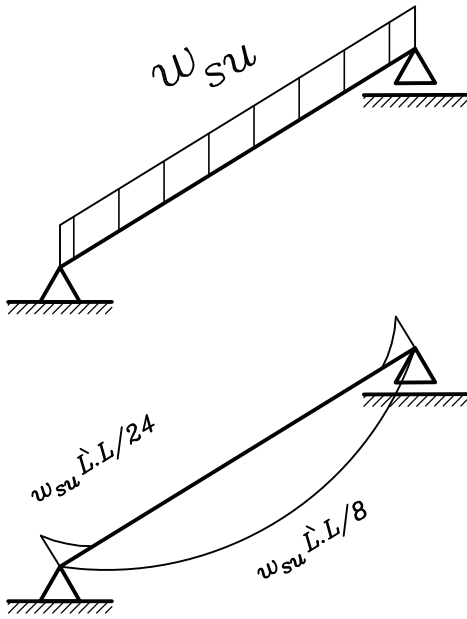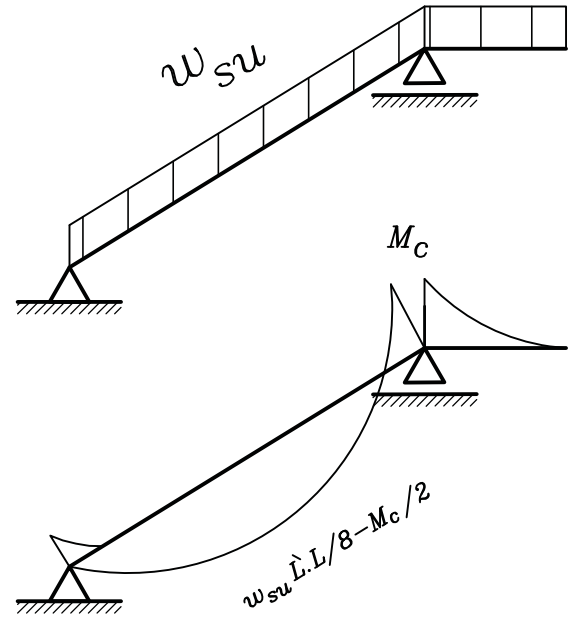## Steps of design

1]Analysis of Slabs

$$w_{su}=1.4[t_s\gamma_c+F.C.]+1.6L.L. \ cos\,\theta \qquad (for \ S.S.)$$

$$w_{su}=\frac{1.4[t_s\delta_c*(e+b)+bh\,\delta_c+5*wt.of \ block]}{(e+b)}+1.4F.C.+1.6L.L.Cos\,\theta$$

$$(for \ H.B.)$$

$$R=y=w_{su}\frac{L^`}{2} \qquad kN/m$$

no cantilever

Case of cantilever
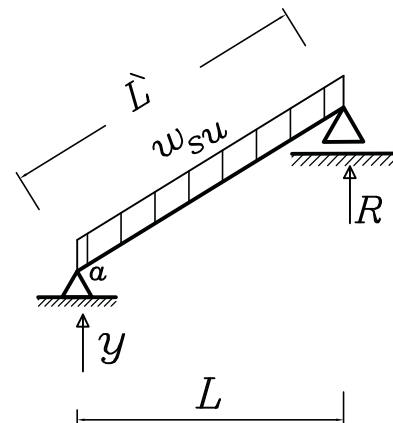
2]Reactions of slabs on beams

3]Analysis of Ridge beam(250*400)

$$\boxed{w = R + o.w} \quad kN/m$$

$$\boxed{R_1 = w * a}$$

$$w \ kN/m`$$
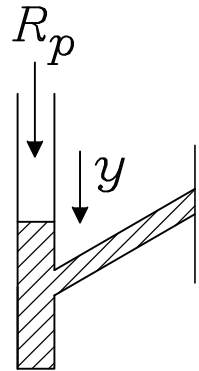

Dist. between posts   a=(2-3)m

R_1

4]Design of Posts

$$\boxed{R_p = R_1 + o.w \ of \ Post}$$
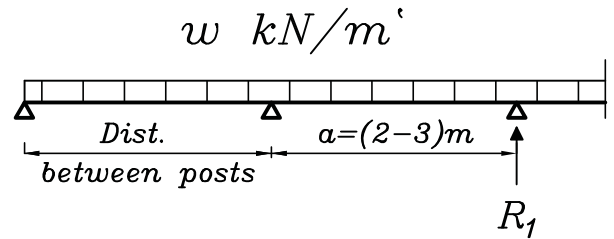
$$R_p = 0.35 A_c f_{cu} + 0.67 A_s f_y \quad \longrightarrow \quad get \ A_s$$

5]Design of Y-beam

$$\boxed{w_y = o.w. + y + \frac{\Sigma R_p}{Span}} \quad kN/m$$

$$\boxed{R_y = w_y * Spacing}$$

R_p

y

$R_p \quad R_p \quad R_p \quad R_p$

Spacing   Spacing

$w_y \ kN/m`$

Spacing   Spacing

R_y

6]Analysis of End beam

$$\boxed{w_{vl.} = o.w + y} \qquad kN/m$$

$$\boxed{R_{vl} = w_{vl} * Spacing}$$

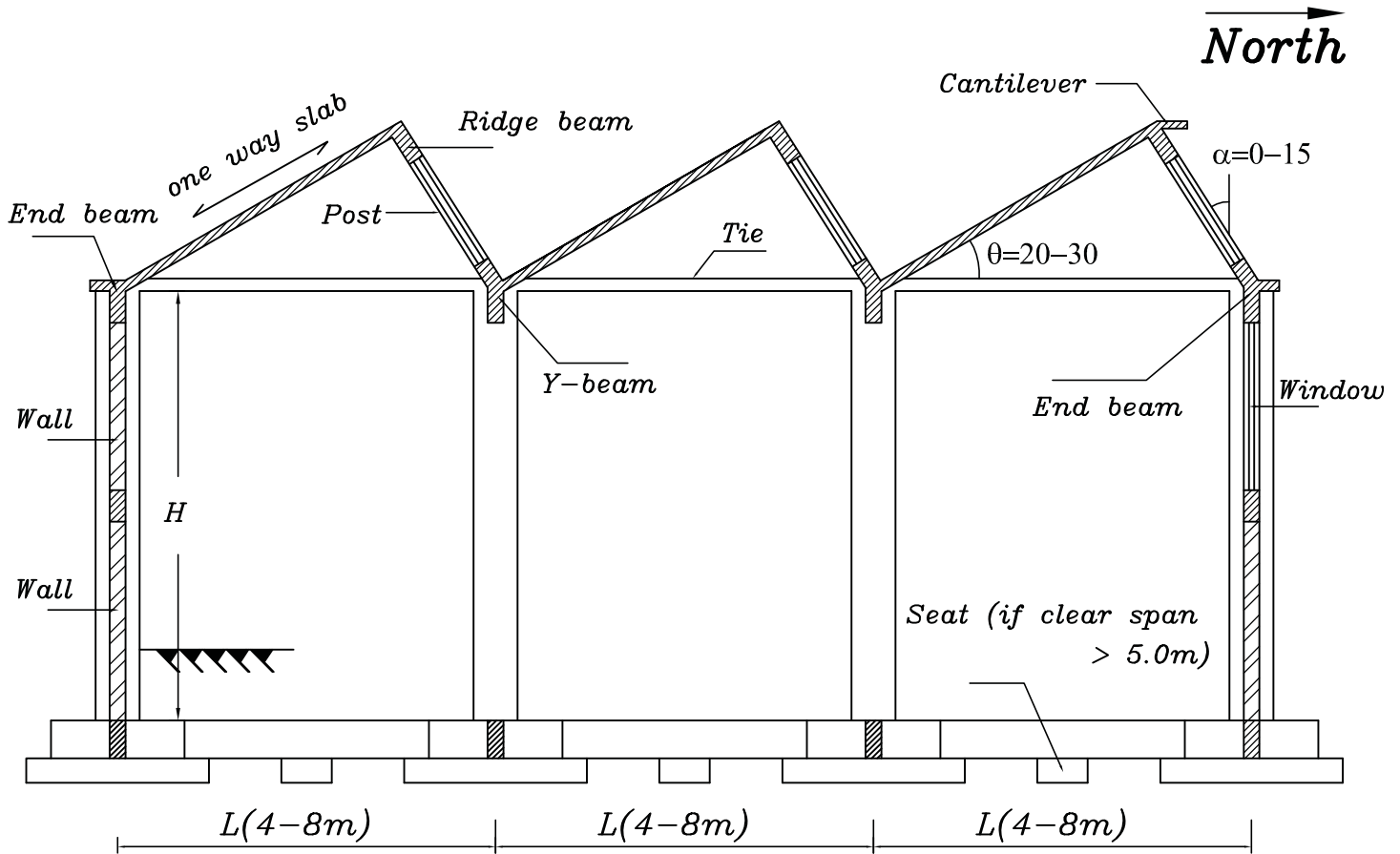$$w_{vl.} kN/m'$$

spacing   spacing

$$R_{vl}$$
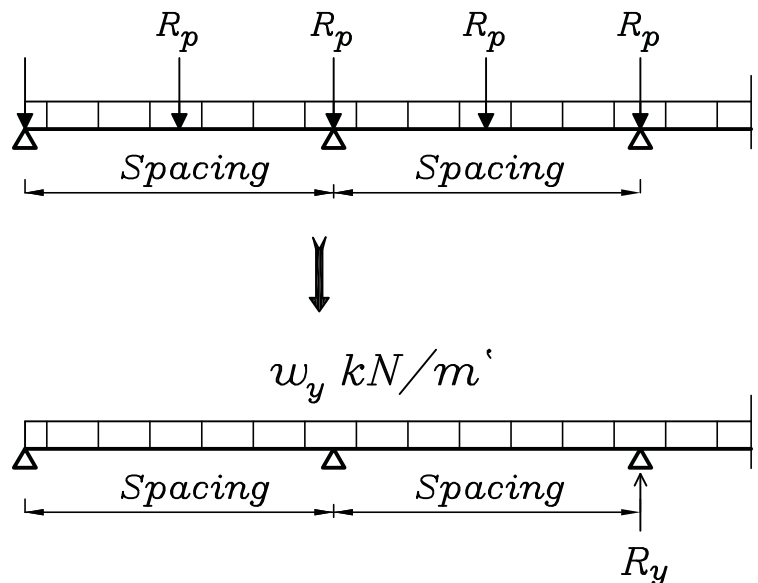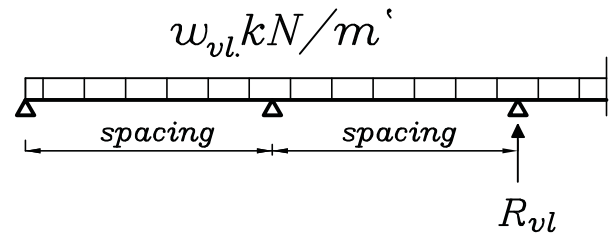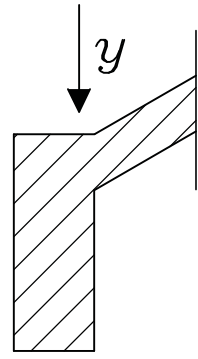
8]Design of Col.

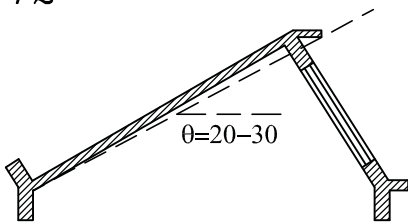$$\boxed{P_{col.} = R_{y-beam}}$$

$$Design \qquad N, M_{add.}$$

b]With Inclined Posts

Saw Tooth Slab Type is used for Span (4—8m)

Concrete Dimensions

—One way Solid Slab   (4 ⟹ 5m)

—One way H.B. Slab   (5 ⟹ 8m)

—Tie (b*b)

—Post (250*250)
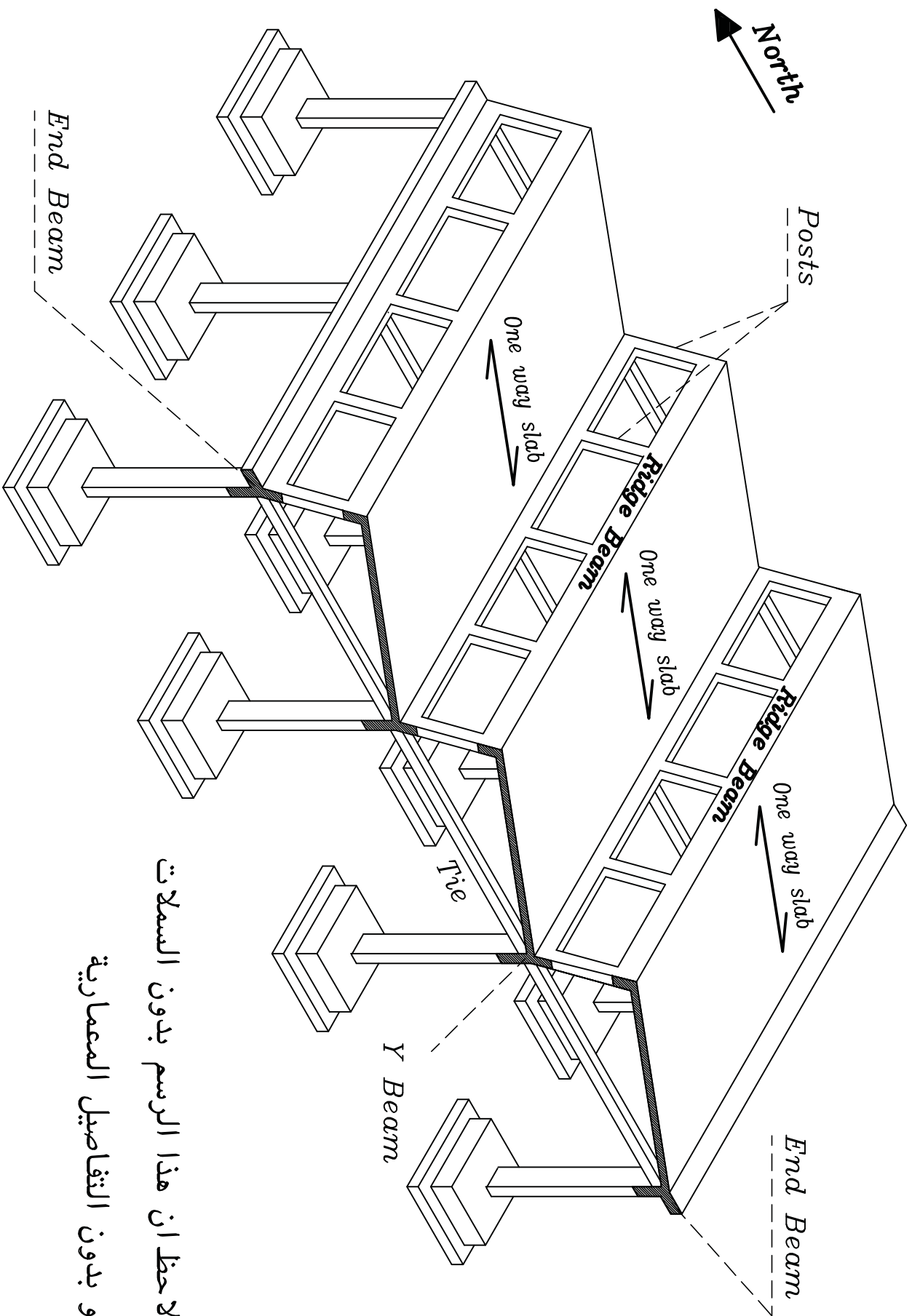
—Distance betwen posts (2 ⟹ 3m)

— $t(col) = \frac{H}{12}$

ـ فائدة الكابولى

١ ـ تقليل زاوية الاضاءة .
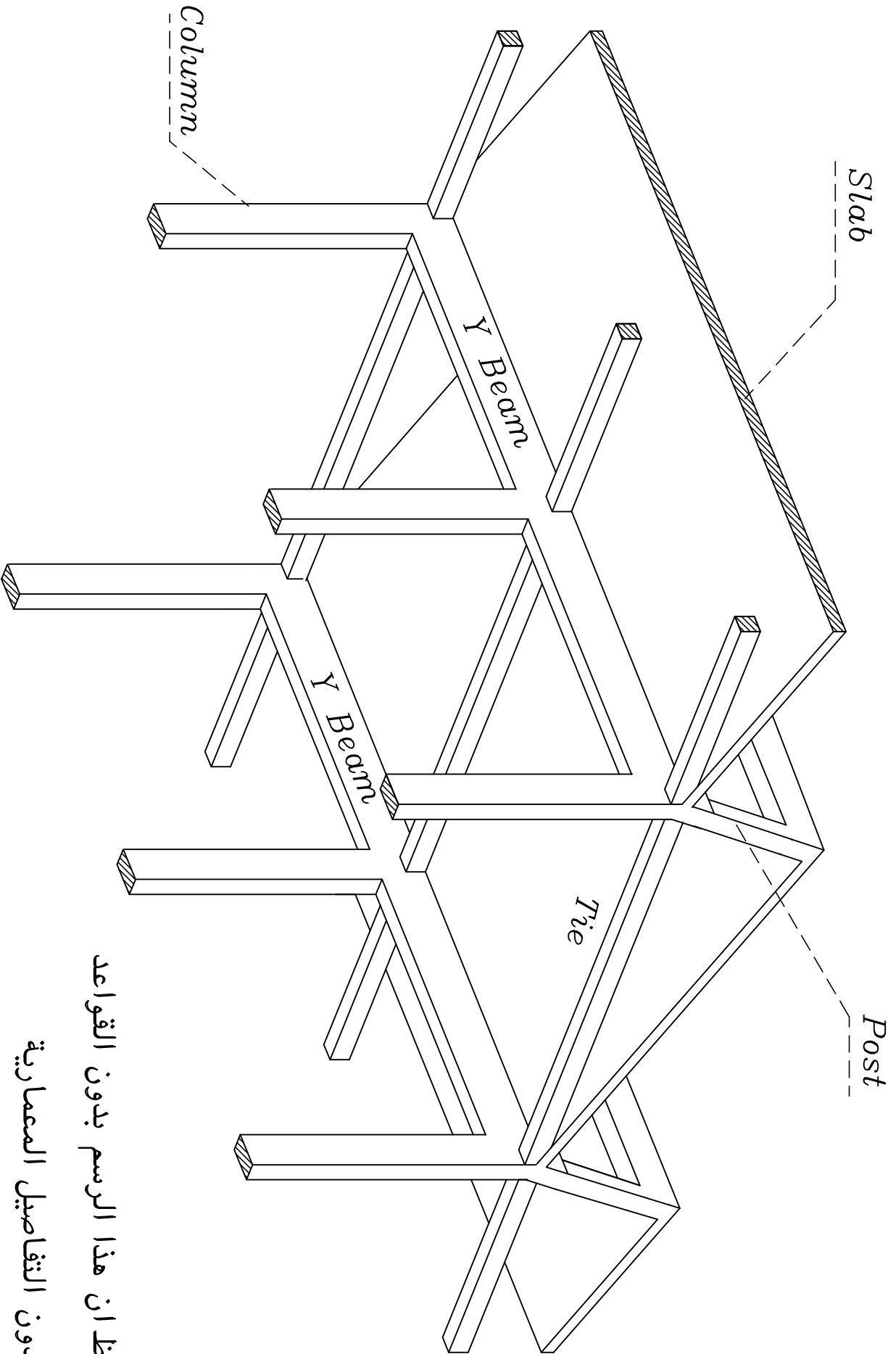
٢- تقليل العزم الموجب للبلاطة

٣ـ عدم سقوط مياه المطر مباشرة على الشباك

By Eng. Ezz El—Din Mostafa & Eng. Yasser M. Samir

System الشكل تشطيب ان الجول

North

End Beam

Posts

One way slab

Ridge Beam

One way slab

Ridge Beam

One way slab

Tie

Y Beam

End Beam

حيث ان الجمل تشطيب ان الجول

لا على ان هذا الارسم يجب تمثيل جميع العناصر

و بحيث الانشائية للسقف المائلة

Column

Slab

Y Beam

Y Beam

Tie

Post

وهو عبارة عن تكوين الإنشائية للمنشأ
وهذا النظام الأكثر شيوعاً من بين الأنظمة الأخرى

KEY PLAN
1:200 → 1:400

Side view

spacing

spacing

spacing

(0.00)

Plan

spacing

spacing

spacing

(0.00)

L(4-8m)

L(4-8m)

L(4-8m)

Elevation
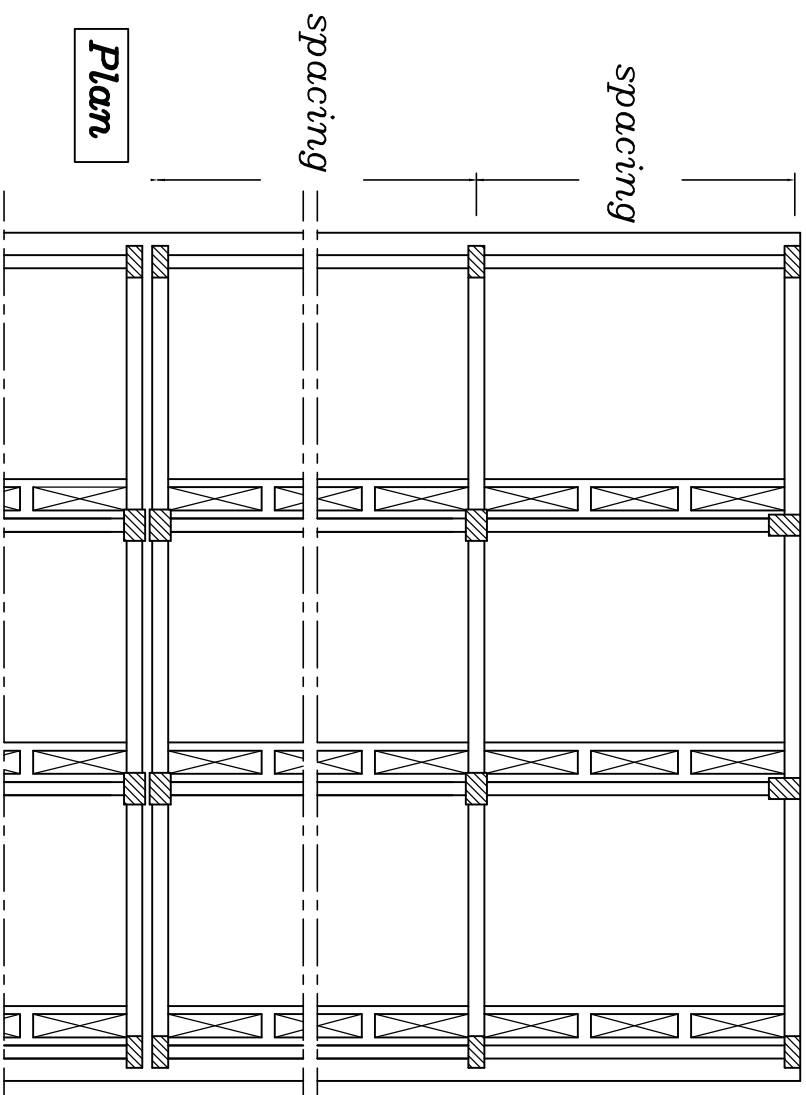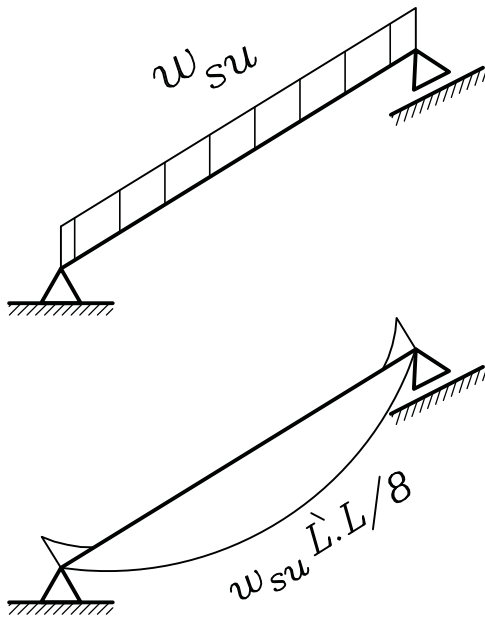
North
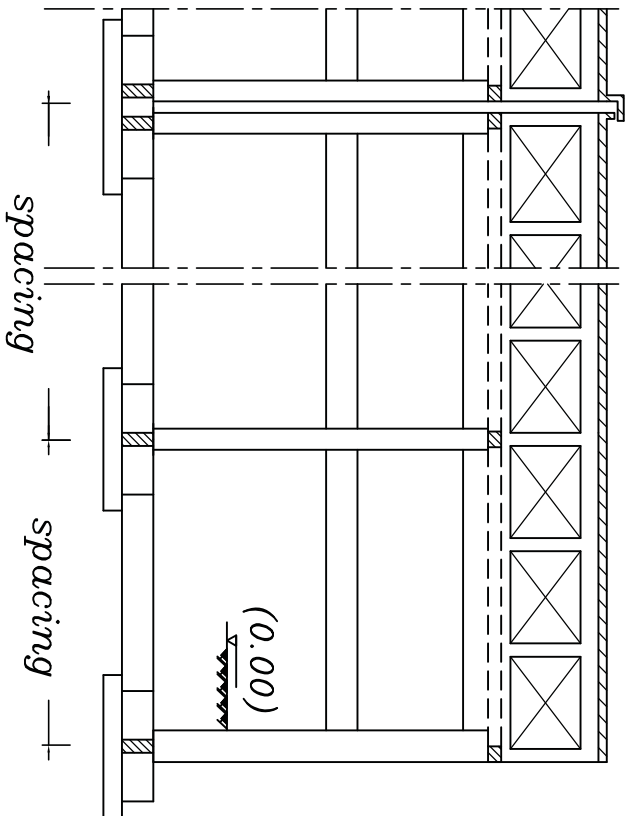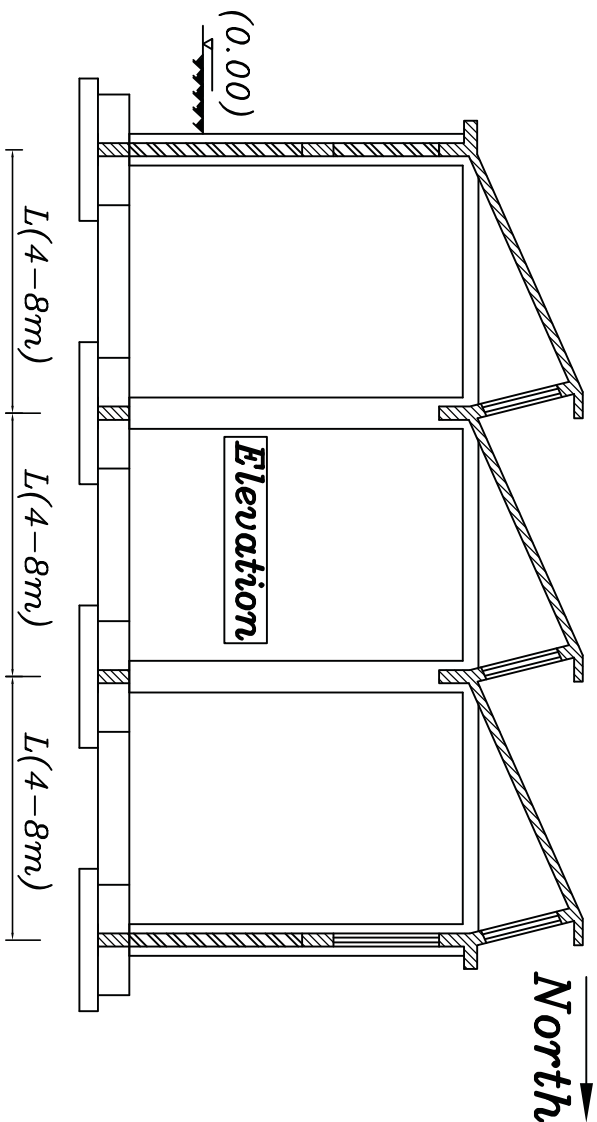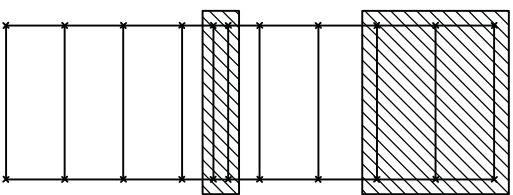
Steps of design
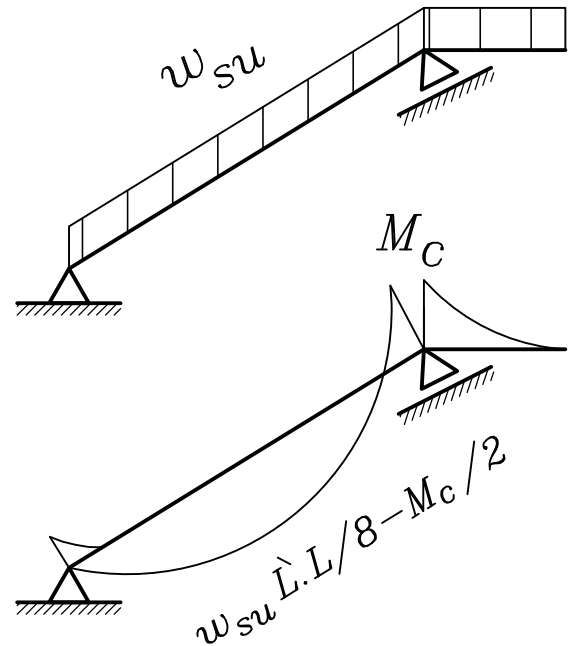
1] Analysis of Slabs

$$w_{su} = 1.4[t_s\gamma_c + F.c.] + 1.6L.L. \cos\theta \quad (for \ S.S.)$$

$$w_{su} = 1.4[t_s\gamma_c + F.c. + 2bh\gamma_c + 10*w.t.of \ Block] + 1.6L.L. \cos\theta$$
$$(for \ H.B.)$$

w_{su}

$w_{su} \grave{L}.L/8$

no cantilever

w_{su}

M_C

$w_{su} \grave{L}.L/8 - M_c/2$

Case of cantilever

2] Reactions of slabs on beams

$\grave{L}$

w_{su}

$R\sin\alpha$

h

R

$x \rightarrow$ α

$R\cos\alpha$

α

y

L

$$\Sigma M_a = 0$$

$$w_{su} \grave{L} \ \frac{L}{2} = R(\cos\alpha)*L + R(\sin\alpha)*h \quad \Longrightarrow \quad get \ R$$
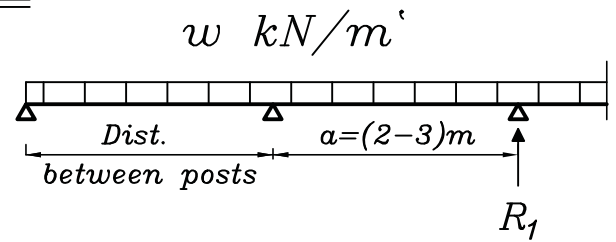
$$\Sigma y = 0 \quad w_{su} \grave{L} - y - R \cos\alpha = 0 \quad \Longrightarrow \quad get \ y$$

$$\Sigma x = 0 \quad x = R \sin\alpha$$

3]Analysis of Ridge beam(250*400)

$$\boxed{w=R+o.w} \quad kN/m$$

$w \ kN/m`$

Dist. between posts

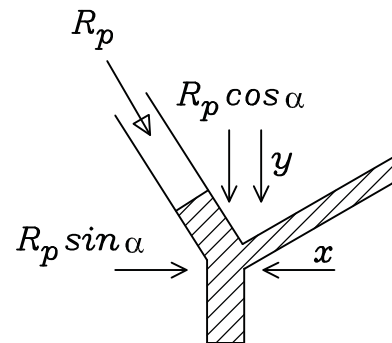$a=(2-3)m$

R_1

$$\boxed{R_1 =w*a}$$

4]Design of Posts

$$\boxed{R_p =R_1 +o.w \ of \ Post}$$

$$R_p =0.35A_c f_{cu} +0.67A_s f_y \quad \longrightarrow \quad get \ A_s$$

5]Design of Y-beam

$$\boxed{w_y =o.w.+y+ \frac{\Sigma R_p Cos\alpha}{Span}} \quad kN/m$$

R_p

$R_p cos\alpha$

y

$R_p sin\alpha$

x

$$\boxed{R_y =w_y *Spacing}$$

$R_p cos\alpha \quad R_p cos\alpha \quad R_p cos\alpha \quad R_p cos\alpha$

Spacing
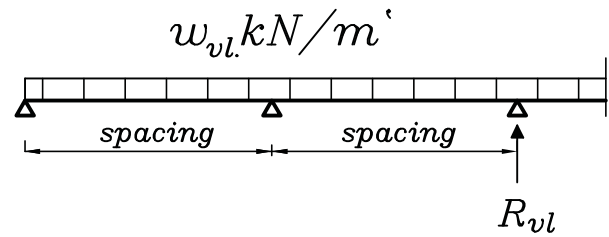
Spacing

$w_y \ kN/m`$

Spacing

Spacing

R_y

6]Analysis of End beam

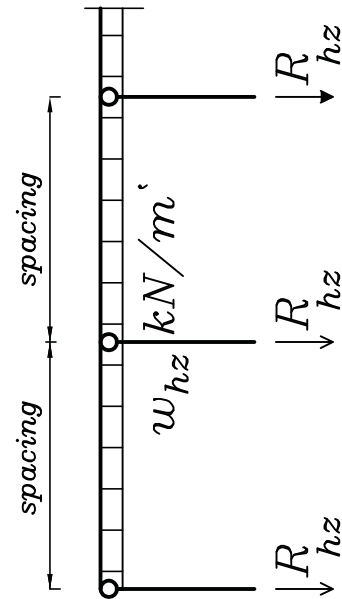## For VL. beam

$$w_{vl.} = o.w + y \qquad kN/m$$

$$R_{vl} = w_{vl} * Spacing$$

For HZ. beam

$$w_{hz} = x \quad kN/m$$

$$R_{hz} = w_{hz} * Spacing$$
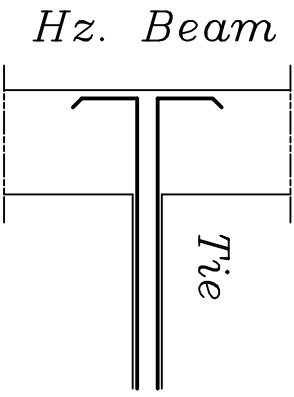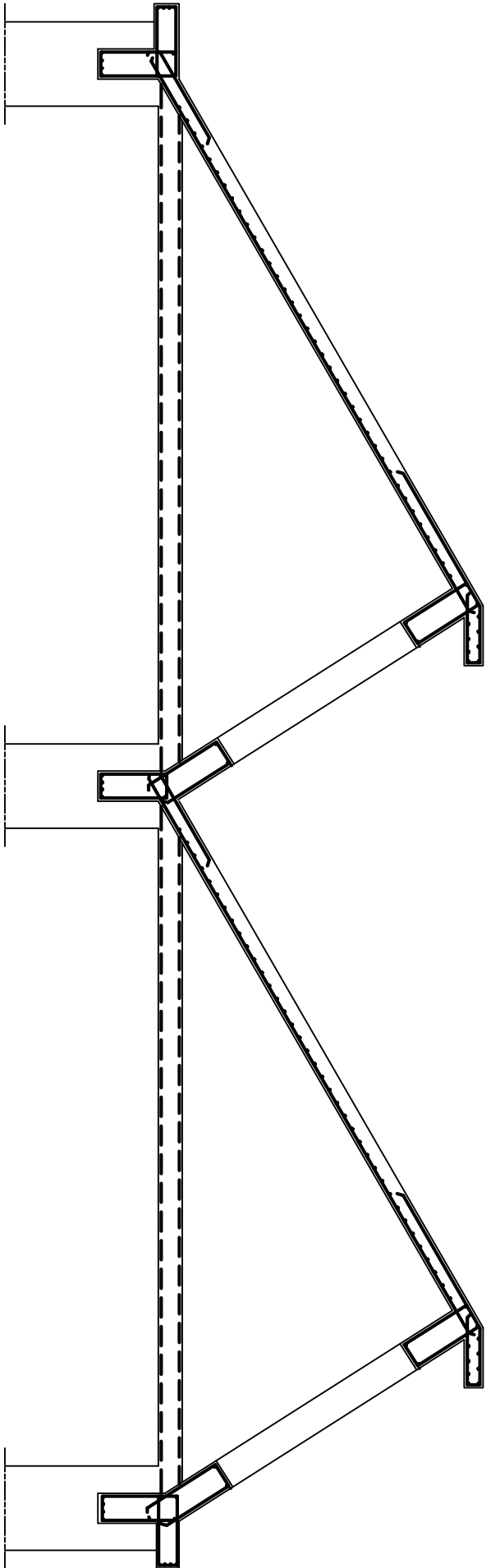

7]Design of Tie

$$T = R_{hz} = w_{hz} * Spacing$$
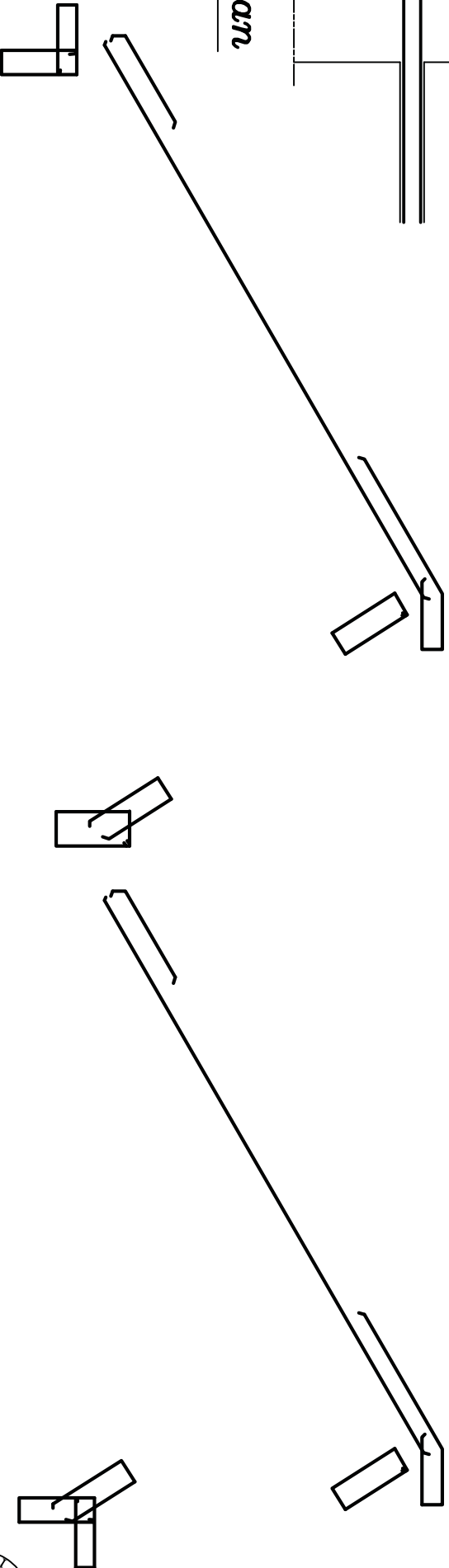
$$A_s = \frac{Tu}{f_y / \gamma_s}$$

8]Design of Col.

$$P_{col.} = R_{y-beam}$$

Design $N, M_{add.}$

Hz. Beam

Plan

Tie

By Eng. Ezz El−Din Mostafa & Eng. Yasser M. Samir

Example

For the given plan and cross−section,

it is required to:
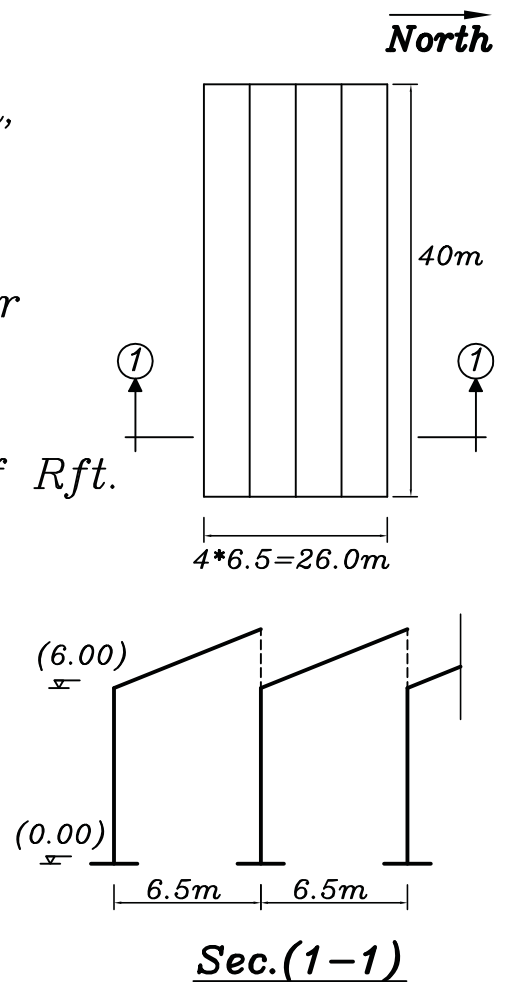
1−Choose the suitable system to cover
  this Area.

2−Design all Slabs and draw plan of Rft.

3−Design Ridge,Column,Post
  and draw details of Rft.

North

40m

① ①

4*6.5=26.0m

(6.00)

(0.00)

6.5m | 6.5m

Sec.(1−1)

$F.C.=1.4kN/m^2$,$L.L=0.5\ kN/m^2$

$f_{cu}=25\ N/mm^2$, $f_y=360\ N/mm^2$

Solution

7.16m

3.0m

θ

6.5m

$\theta=tan^{-1}(\frac{3}{6.5})=24.78$

$t=\dfrac{716}{16}=44.75cm$

take t=25 cm [20cm+5cm]

$w_{su}=\dfrac{1.4[t_s\delta_c*(e+b)+bh\delta_c+5*wt.of\ block]}{(e+b)}+1.4F.C.+1.6L.L.Cos\theta$

$w_{su}=\dfrac{1.4[0.05*25*0.5+0.1*0.2*25+5*0.16]}{0.50}+1.4*1.4+1.6*0.5*0.91$

$=\ 8.08\ kN/m^2$

$w_{su/Rib}=0.5*8.2=4.04kN/m^`$

4.04kN/m

B.M.D.

7.83

7.83

1

23.50

KEY PLAN
1:200 → 1:400

Side view

Elevation

Plan

5.0m 5.0m

End B(300*500)

C(300*600)

Y-B(300*500)

2Φ10/rib
2Φ16/rib
2Φ10/rib

Tie(300*300)

Tie(300*300)

250
200 50

C(400*600)

5Φ8/m
4Φ8/m

Y-B(250*500)

2Φ10/rib
2Φ16/rib
2Φ10/rib

250
200 50

Tie(300*300)

Tie(300*300)

(-1.50)
(0.00)
(6.00)
(4.00)

6.50m 6.50m 6.50m 6.50m

-0.60
-0.60
0.30m
-0.60

North

3.0m

5.0m 5.0m

-0.40
(0.00)

Page 17
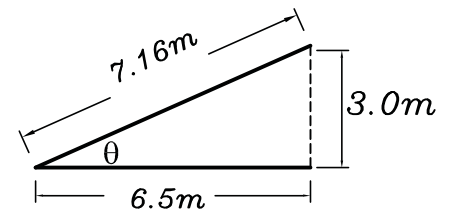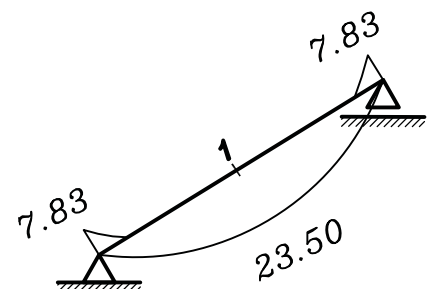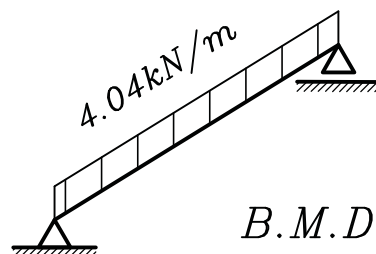
Sec. (1-1)

$$220 = C_1 \sqrt{\frac{23.50*10^6}{500*25}} \qquad C_1 = 5.07 \qquad J = 0.826$$

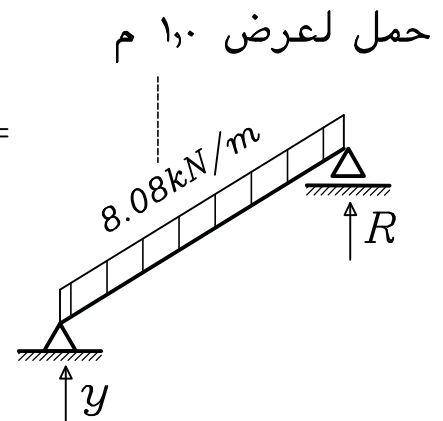$$A_s = \frac{23.50*10^6}{0.826*360*220} = 3.59 cm^2/rib$$

$$A_s = 2\phi 16/rib$$

Sec. (2-2)

$$A_s = 2\phi 10/rib$$

2]Reactions of slabs on beams

$$R = y = w_{su} \frac{L`}{2} \qquad kN/m$$

$$R = y = 8.08*7.16/2 = 28.93 \ kN/m$$

حمل لعرض ١,٠ م

8.08kN/m
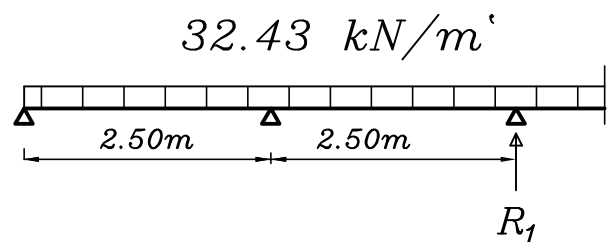
R

y

3]Design of Ridge beam(250*400)

$$w = R + o.w \qquad kN/m$$

$$w = 28.93 + 0.25*0.40*25*1.40$$

$$w = 32.43 \ kN/m$$

$$R_1 = 32.43*2.5 = 81.08 kN$$

32.43 kN/m'

2.50m   2.50m

R_1
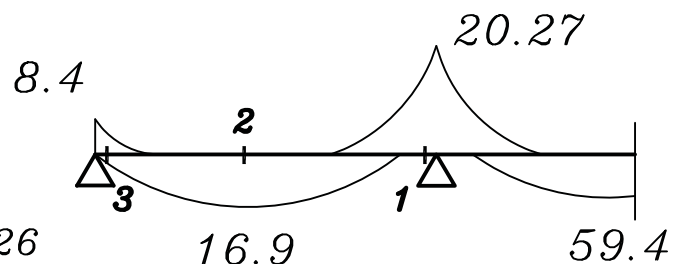
Sec 1 $M_{u.l.} = 20.27 \ kN.m$

$$350 = C_1 \sqrt{\frac{20.27*10^6}{25*250}} \longrightarrow C_1 = 6.1$$

$$\longrightarrow J = 0.826$$

$$A_s = \frac{20.27*10^6}{360*0.826*350} = 194.7 \ mm^2$$

8.4

20.27

2

3   1

16.9   59.4

Use min $A_s = 2\phi 12$

Detail of reinforcement of Ridge beam

5Ø8/m

2Ø12

2Ø12

2Ø10

2Ø12

2Ø12

1

1

2Ø10

2Ø12

2

2

2Ø12

2Ø10

2Ø12

0.4

2Ø12

0.25

2Ø12

Sec.(1-1)

0.4

2Ø10

0.25

2Ø12
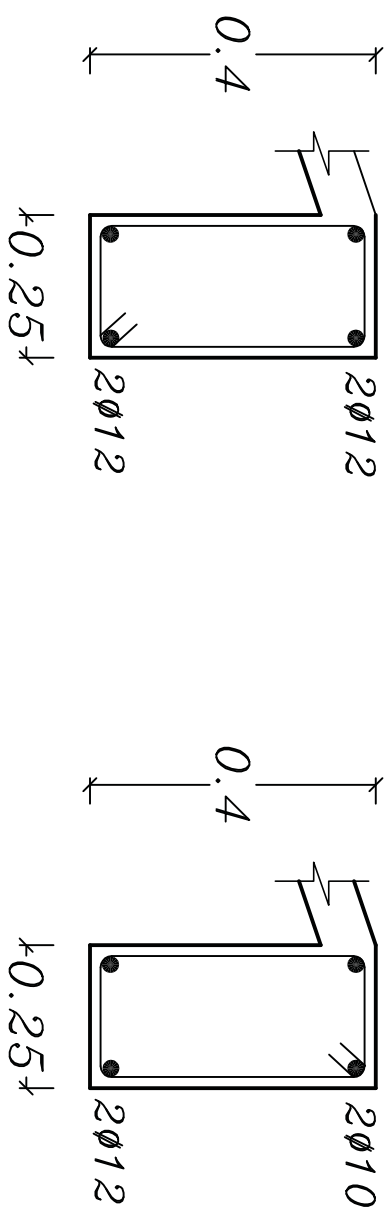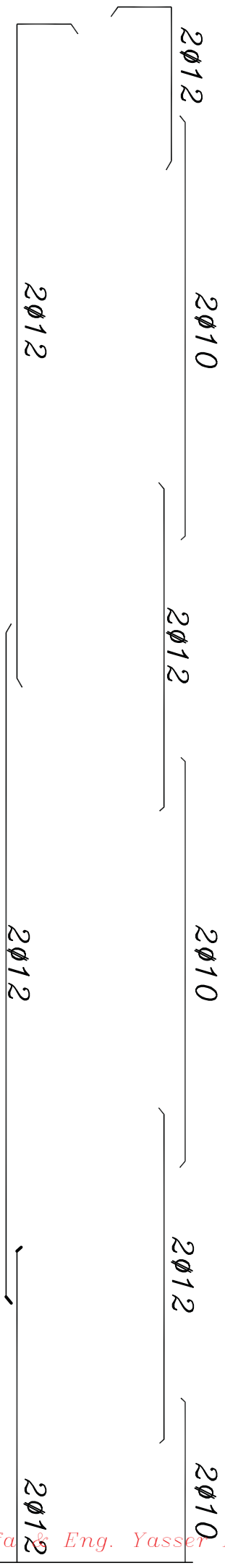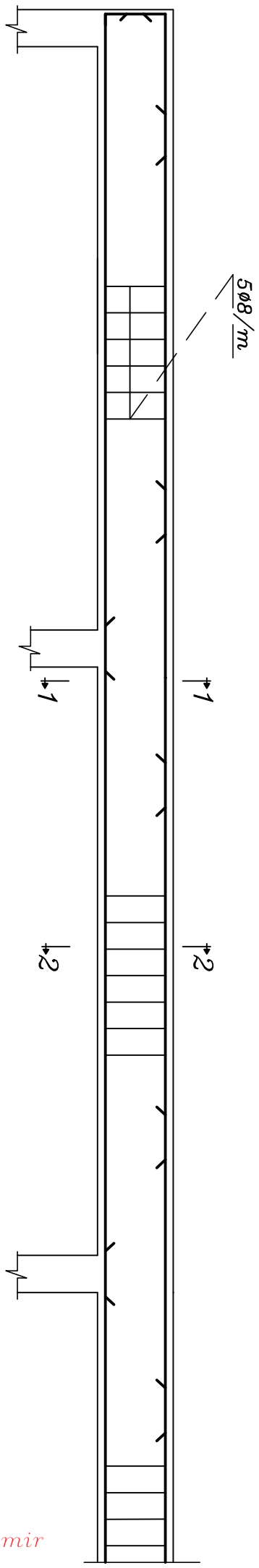
Sec.(2-2)
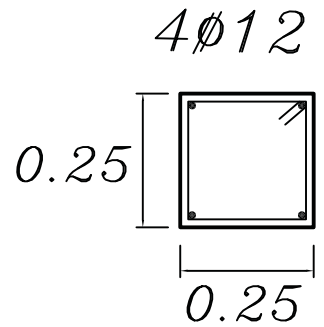
4]Design of Posts

$R_p = R_1 + o.w$ of Post

$R_p = 81.08 + 0.25*0.25*3*25*1.40 = 87.64 kN$

$87.64*10^3 = 0.35*250*250*25 + 0.67 A_s f_y$

$A_s = -ve \longrightarrow A_s = 4\phi12$

$4\phi12$

0.25

0.25

5]Design of Y-beam (300*500)
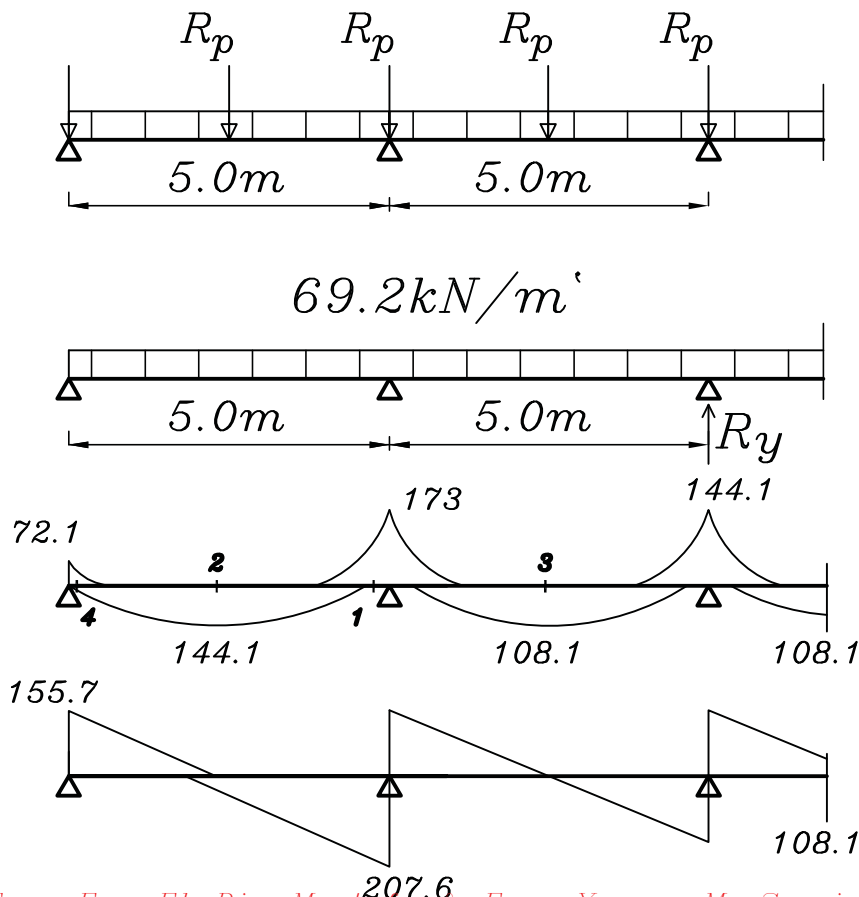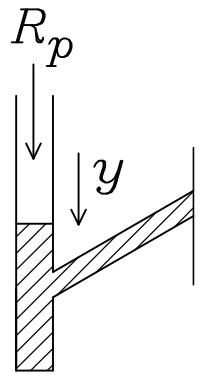
$w_y = o.w. + y + \dfrac{\Sigma R_p}{Span}$ kN/m

$w_y = 0.30*0.50*25*1.40 + 28.93 + \dfrac{2*87.64}{5.0}$

$w_y = 69.2 kN/m$

$R_y = 69.2*5.0 = 346$ kN

R_p

y

نصيب البحر الواحد
هو حمل فى وسطه و نصف حمل من
كل ركيزة

R_p R_p R_p R_p

5.0m   5.0m

$69.2 kN/m`$

5.0m   5.0m R_y

173   144.1

72.1

2   3

4   1

144.1   108.1   108.1

155.7

108.1

207.6

Sec 1 $M_{u.l.} = 173$ kN.m

$$450 = C_1 \sqrt{\frac{173 * 10^6}{25 * 300}} \longrightarrow C_1 = 2.96 \longrightarrow J = 0.74$$

$$A_s = \frac{173 * 10^6}{360 * 0.74 * 450} = 1443 \ mm^2 \qquad \boldsymbol{A_s = 6\phi18}$$

Sec 2 $M_{u.l.} = 144.1$ kN.m

$$450 = C_1 \sqrt{\frac{144.1 * 10^6}{25 * 300}} \longrightarrow C_1 = 3.24 \longrightarrow J = 0.76$$

$$A_s = \frac{144.1 * 10^6}{360 * 0.76 * 450} = 1170 \ mm^2 \qquad \boldsymbol{A_s = 5\phi18}$$

Sec 3 $M_{u.l.} = 108.1$ kN.m

$$450 = C_1 \sqrt{\frac{108.1 * 10^6}{25 * 300}} \longrightarrow C_1 = 3.75 \longrightarrow J = 0.79$$

$$A_s = \frac{108.1 * 10^6}{360 * 0.79 * 450} = 845 \ mm^2 \qquad \boldsymbol{A_s = 4\phi18}$$

Sec 4 $M_{u.l.} = 72.1$ kN.m

$$450 = C_1 \sqrt{\frac{72.1 * 10^6}{25 * 300}} \longrightarrow C_1 = 4.6 \longrightarrow J = 0.82$$

$$A_s = \frac{72.1 * 10^6}{360 * 0.82 * 450} = 543 \ mm^2 \qquad \boldsymbol{A_s = 3\phi16}$$

$$\text{check } A_{smin} \quad safe$$

Check shear

$Q_{su} = 207.6 kN$

$$q_{su} = \frac{Q_{cr}}{bd} = \frac{207.6 * 10}{300 * 450} = 1.54 \ N/mm^2$$

$$q_{cu} = 0.24 \sqrt{\frac{25}{1.5}} = 0.98 \ N/mm^2$$

$$q_{max} = 0.7 \sqrt{\frac{25}{1.5}} = 2.86 \ N/mm^2 \qquad \boldsymbol{q_{cu} < q_u < q_{umax}}$$

$$q_u - \frac{q_{cu}}{2} = \frac{nA_s\,f_y\,/\gamma_s}{bS}$$

assume $n=2$ $A_s = 78.5mm^2 = \emptyset 10$

$$1.54 - \frac{0.98}{2} = \frac{2*78.5*240/1.15}{300*S} \quad \longrightarrow \quad S=104mm$$

$$No.of\ stirrups/m' = \frac{1000}{S} = 9.7 \qquad \textbf{Take Stirrups \quad 10\emptyset 10/m'}$$

6]Analysis of End beam

$w_{vl.} = o.w + y \qquad kN/m$

$w_{vl.} = 0.25*0.50*25*1.40 + 28.93$

$w_{vl.} = 33.31 kN/m$

$R_{vl.} = 33.31*5.0 = 166.53 kN$

$Y-beam$ ثم تصمم مثل ال

$33.31 kN/m'$

5.0m   5.0m

R_{vl}

Detail of reinforcement of Y- beam

10φ10/m

3φ16

5.0

2φ10

2φ18
3φ18

3φ18
3φ18

2φ18
2φ18

2φ10

5.0

3φ18
2φ18

2φ18
2φ18

2φ10

Sec.(1-1)

0.5

0.25

6φ18

2φ18

Sec.(2-2)

0.5

0.25

2φ10

5φ18

Sec.(3-3)

0.5

0.25

2φ10

4φ18

Sec.(4-4)

0.5

0.25

3φ16

3φ18

By Eng. Ezz El-Din Mostafa & Eng. Yasser M. Samir

Page **23**
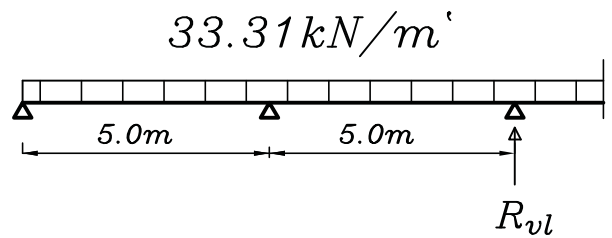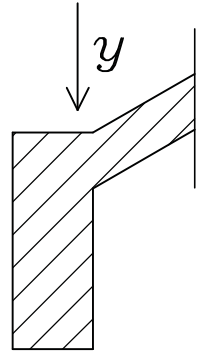
8] Design of Col. (400*600)

$P_{col.} = 341.81 \ kN$

$$\lambda_{b_{in}} = \frac{1.3*6.75}{0.60} = 14.63 \qquad\qquad \lambda_{b_{out}} = \frac{1.2*6.25}{0.40} = 18.75$$

Buckling outside plan

$$\delta_b = \frac{\lambda_b^2 \ b}{2000} = \frac{18.75^2 *0.40}{2000} = 0.07m$$

$M_{add} = 341.81*0.07 = 24.03 kN.m$

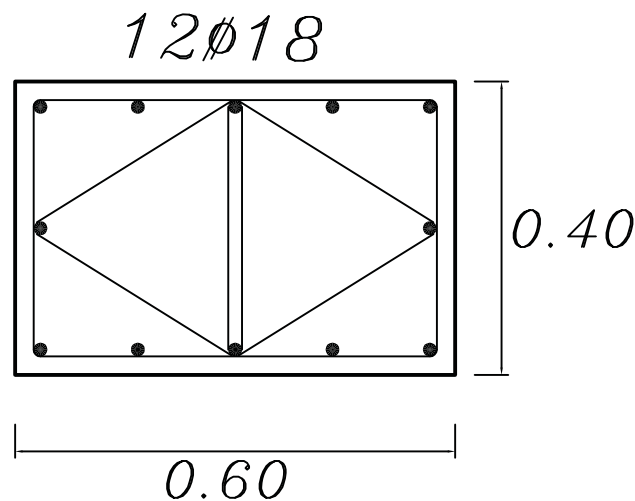$$\frac{N_{u.l.}}{btf_{cu}} = \frac{341.81*10^3}{400*600*25} = 0.06 \qquad\qquad \zeta = \frac{400-100}{400} = 0.75$$

$$\frac{M_{u.l.}}{bt^2f_{cu}} = \frac{24.03*10^6}{600*400^2 \ *25} = 0.01$$

$\rho < 1$ Take $\rho = 1$

$$A_{S \ min} = \frac{0.25+0.052*18.75}{100} *400*600 = 2940 \ mm^2$$

$A_s = 12 \ \phi \ 18$

12Ø18

0.40

0.60

Example

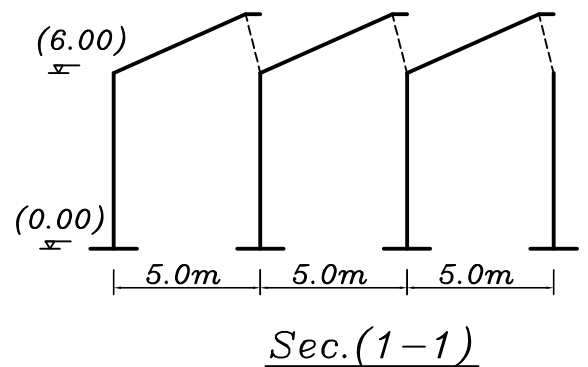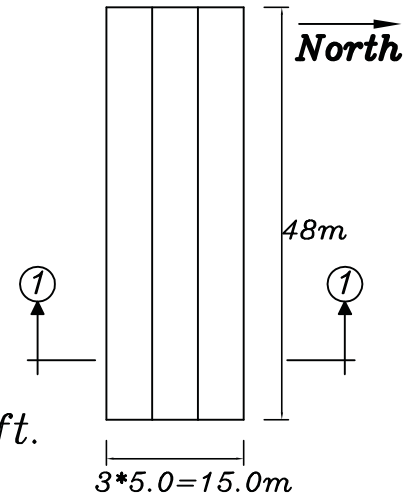For the given plan and cross−section,

it is required to:

1−Choose the suitable system to cover
 this Area.

2−Design all Slabs and draw plan of Rft.

3−Design the Post,Column,Tie
 and draw details of Rft.

$F.C.=1.5kN/m^2$, $L.L=0.5\ kN/m^2$

$f_{cu}=25\ N/mm^2$, $f_y=360\ N/mm^2$

3*5.0=15.0m

Sec.(1−1)

Solution

$t_s = \dfrac{492}{24} = 20.5cm$

$t_{s_{min}} = \dfrac{492}{35} = 14.06cm$

take $t_S = 16\ cm$ (Check def.)

$w_{su}=1.4[t_s\,\gamma_c+F.c.]+1.6\ L.L.Cos\theta$

$w_{su}=1.4[0.16*25+1.5]+1.6*0.5*0.91$

$w_{su}=8.43kN/m^2$

$\theta=tan^{-1}(\dfrac{2}{4.5})=23.96$

$\alpha=tan^{-1}(\dfrac{0.5}{2.0})=14.04$

B.M.D.

1.06

7.78

22.80

8.43kN/m

8.50kN/m

KEY PLAN
1:200 → 1:400

Side view

6.0m   6.0m

(0.00)

−0.40

0.25

(8.00)

(6.00)
(5.40)

(4.00)

(0.00)

(−1.50)

5.0m   5.0m   5.0m

Elevation

−0.60

0.30m

−0.60

North

(4.00)

2.0m

Plan

6.0m   6.0m

Tie(300*300)   C(300*600)   End B(250*600)
                              ⓰⓪
                RidgeB(250*400)

Tie(300*300)   C(400*600)   Y−B(250*600)
                              ⓰⓪
                RidgeB(250*400)

Tie(300*300)   Y−B(250*600)
                              ⓰⓪
                RidgeB(250*400)
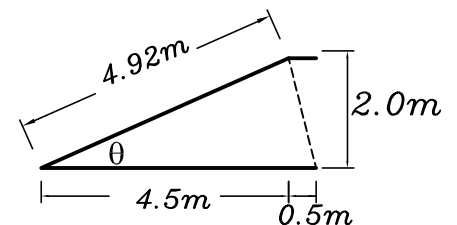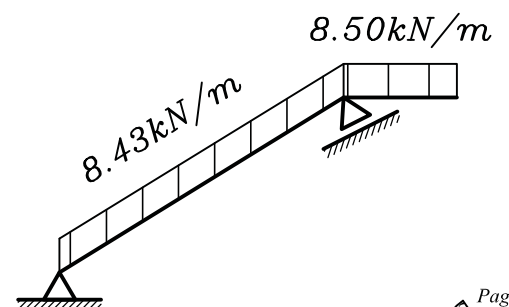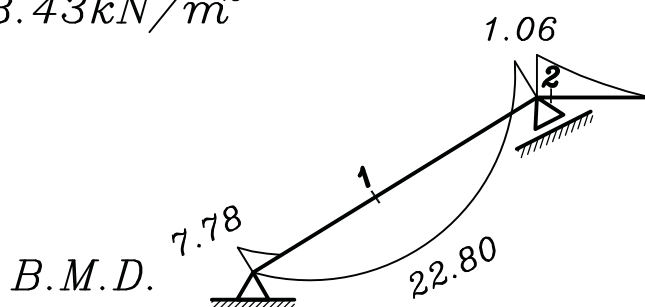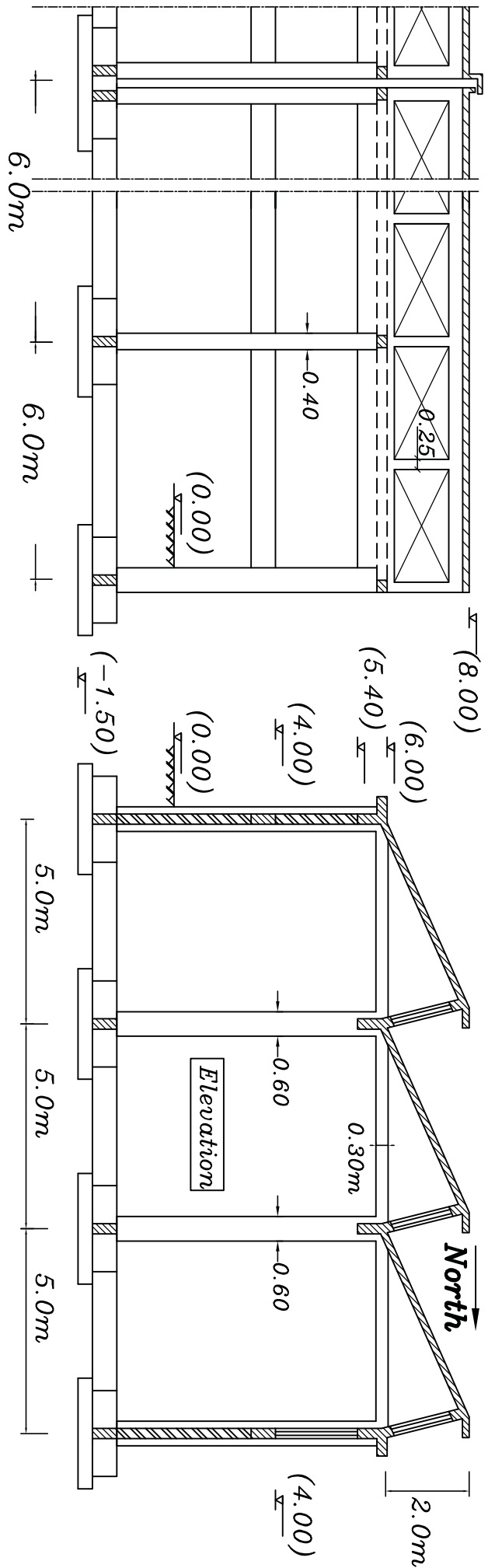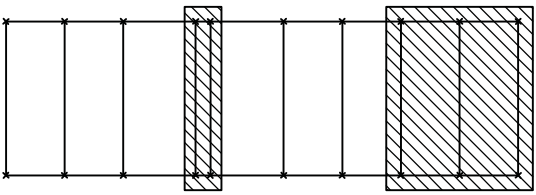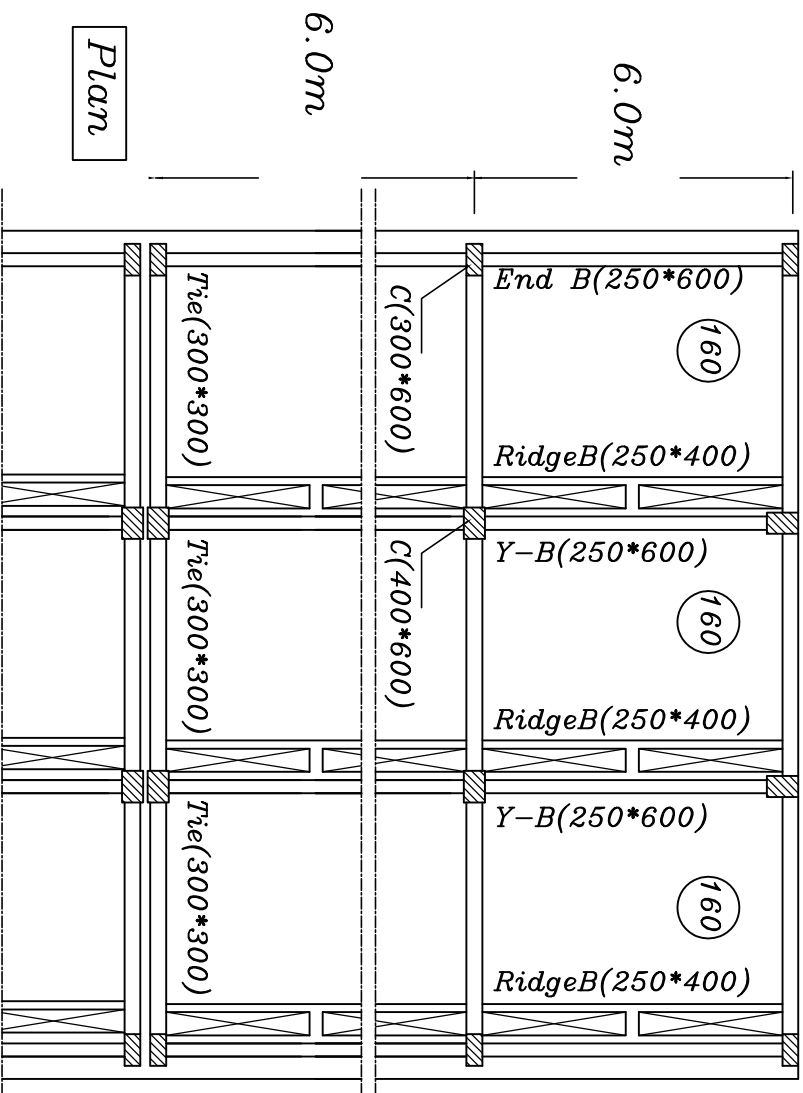
Sec. (1-1)

$$140 = C_1\sqrt{\frac{22.80*10^6}{1000*25}} \qquad C_1 = 4.64 \qquad J = 0.821$$

$$A_s = \frac{22.80*10^6}{0.821*360*140} = 5.51 cm^2/m`$$

$$A_s = 5\phi 12/m`$$

Sec. (2-2)

$$A_s = 5\phi 8/m`$$

2]Reactions of slabs on beams

$$\Sigma M_a = 0$$
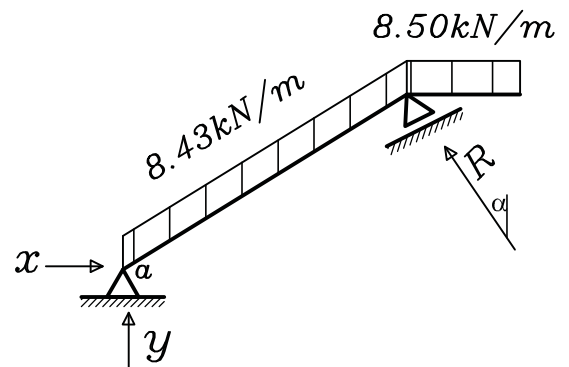
$$8.43*4.92*4.5/2 + 8.50*0.5*4.75 = Rcos\ \alpha*4.5 + Rsin\ \alpha*2.0$$

$$R = 23.40 kN/m$$

$$\Sigma y = o$$

$$8.43*4.92 + 8.50*0.5 = Rcos\alpha + y$$

$$y = 23.02 kN/m$$

$$\Sigma x = o \qquad x = Rsin\alpha = 5.68 kN/m$$

3]Analysis of Ridge beam(250*400)

$$w = R + o.w \qquad kN/m$$

$$w = 23.40 + 0.25*0.40*25*1.40$$

$$w = 26.90\ kN/m$$

$$R_1 = 26.90*3.0 = 80.70\ kN$$

ثم تصمم كما سبق فى المسالة الاولى

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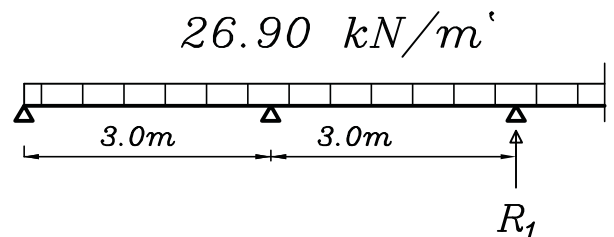
4]Design of Posts

$R_p = R_1 + o.w$ of Post

$R_p = 80.70 + 0.25*0.25*2*25*1.40 = 85.08kN$

$85.08*10^3 = 0.35*250*250*25 + 0.67 A_s f_y$
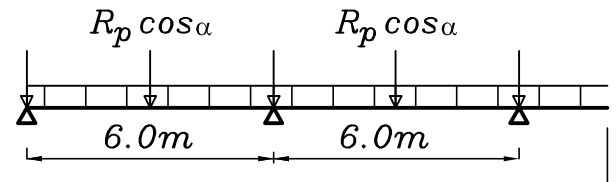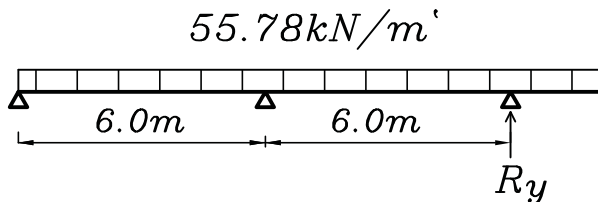
$A_s = -ve \quad \longrightarrow \quad A_s = 4\phi 12$

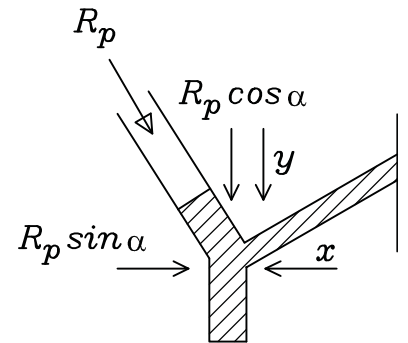# 5]Design of Y-beam

$w_y = o.w. + y + \dfrac{\Sigma R_p \cos\alpha}{Span} \quad kN/m$

$w_y = 0.25*0.60*25*1.40 + 23.02 + \dfrac{2*85.08\cos\alpha}{6.0}$

$w_y = 55.78kN/m$

$R_y = 55.78*6.0 = 334.68 \quad kN$

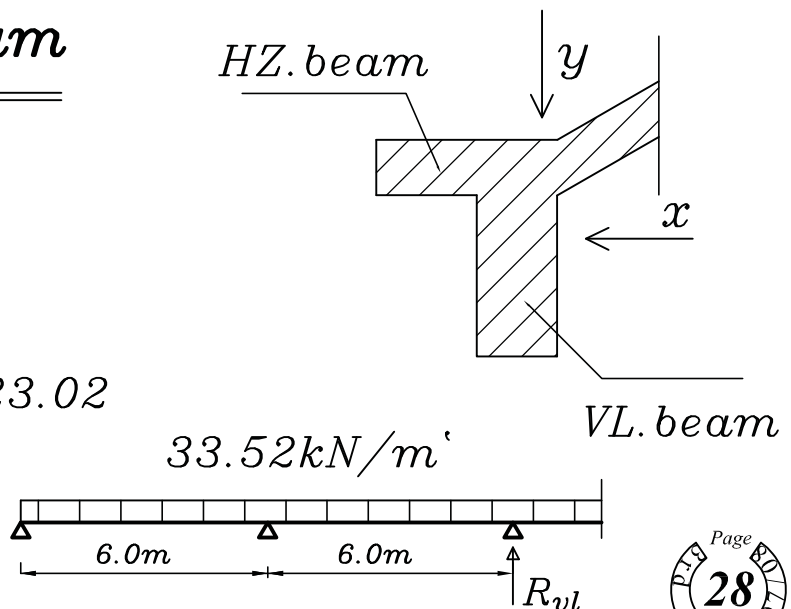ثم تصمم كما سبق فى المسالة الاولى

6]Analysis of End beam

For VL. beam

$w_{vl.} = o.w + y \quad\quad kN/m$

$w_{vl.} = 0.25*0.60*25*1.40*2 + 23.02$

$w_{vl.} = 33.52kN/m$

$R_{vl.} = 33.52*6.0 = 201.12kN$

ثم تصمم مثل الـ Y-beam

For HZ. beam

$w_{hz} = x = 5.68 kN/m$

$R_{hz} = 5.68 * 6.0 = 34.08 kN$

min. RFT

(Bending moment diagram values: 2, 12.8, 17.04, 17.04, 20.4, 8.5)

(Right diagram: 6.0m, 6.0m spans with ties, load $5.68 kN/m'$, $\downarrow R_{hz}$, Tie, Tie, Tie)
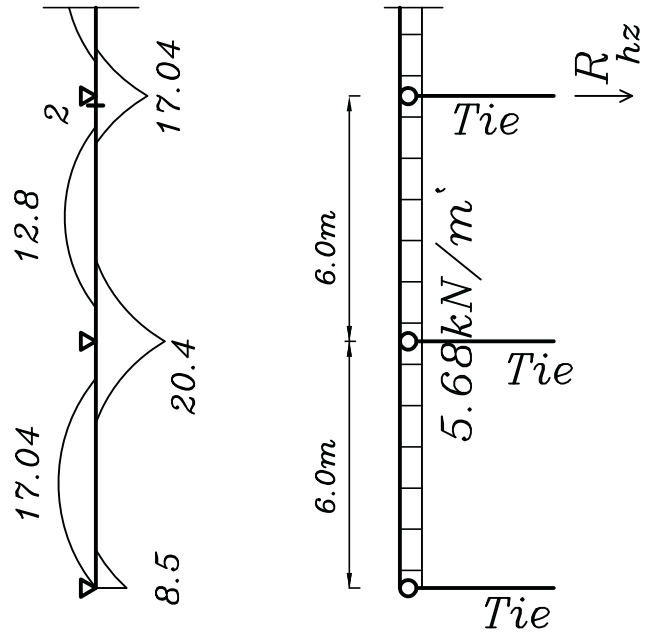
7]Design of Tie

$T = R_{hz} = 34.08 kN$

$A_s = \dfrac{34.08 * 10^3}{360/1.15} = 109 mm^2$

$A_s = 4\phi 12$

8]Design of Col. (400*600)

$P_{col.} = 334.68 \ kN$

$\lambda_{b_{in}} = \dfrac{1.3*6.75}{0.60} = 14.63$

$\lambda_{b_{out}} = \dfrac{1.2*6.15}{0.40} = 18.45$

Buckling outside plan

$\delta_b = \dfrac{\lambda_b^2 \ b}{2000} = \dfrac{18.45^2 *0.40}{2000} = 0.07m$

$M_{add} = 334.68*0.07 = 22.79 kN.m$

$\dfrac{N_{u.l.}}{bt f_{cu}} = \dfrac{334.68*10^3}{400*600*25} = 0.06$
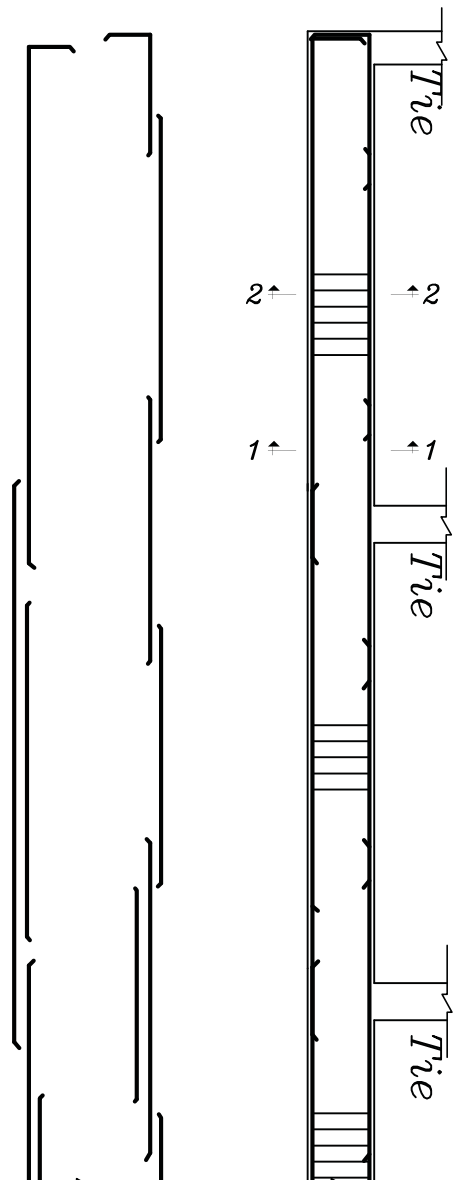
$\zeta = \dfrac{400-100}{400} = 0.75$

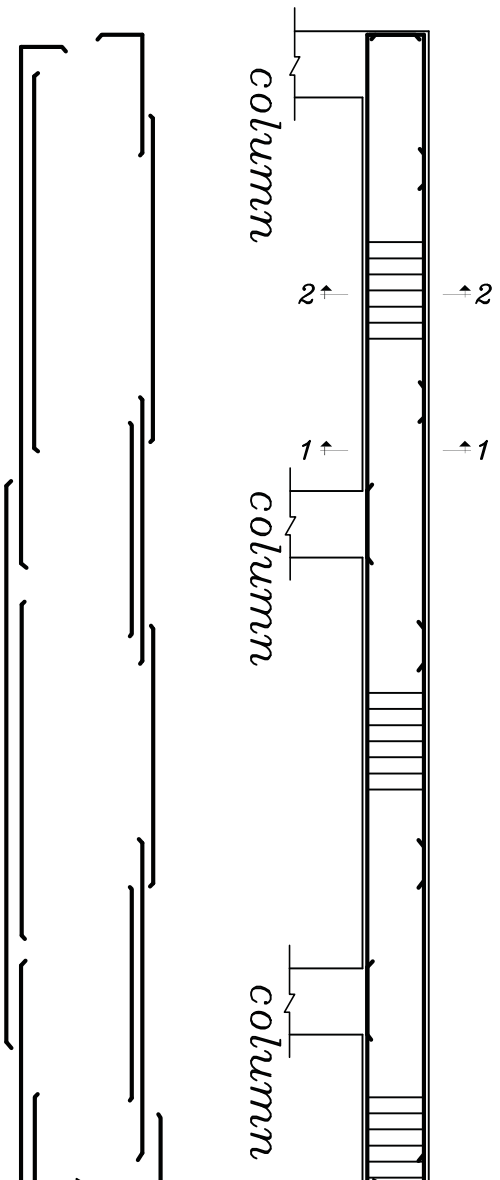$\dfrac{M_{u.l.}}{bt^2 f_{cu}} = \dfrac{22.79*10^6}{600*400^2 *25} = 0.009$

$\rho < 1$ Take $\rho = 1$

$A_{smin} = \dfrac{0.25+0.052*18.45}{100} *400*600 = 2903mm^2$

Plan of Rft. for HL. Beam

Tie

2 2

1 1

Tie

Tie

Elev. of Rft. for VL. Beam

column

2 2

1 1

column

column

Details of R.F.T.

Sec.1-1
12ϕ18
0.60
0.40

4ϕ12

Sec.2-2
4ϕ12
0.25
0.25

Sec.2-2
4ϕ13
0.30
0.30

0.30m

5ϕ8/m
5ϕ8/m
5ϕ8/m
5ϕ12/m
5ϕ8/m
5ϕ8/m
5ϕ8/m
5ϕ8/m
5ϕ8/m
5ϕ8/m
5ϕ12/m
5ϕ8/m
5ϕ8/m
5ϕ8/m
5ϕ8/m
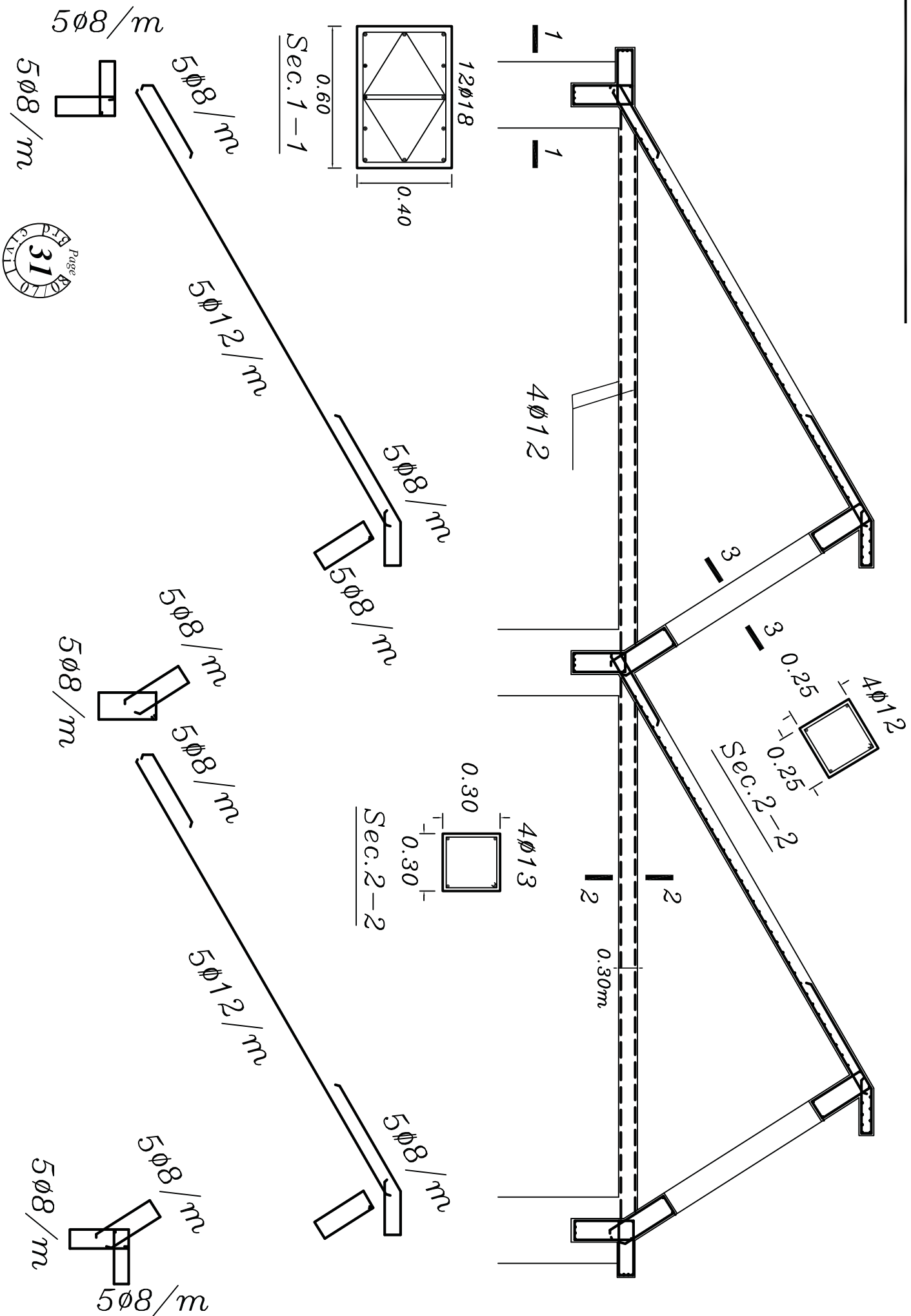
2]Saw Tooth Girder Type
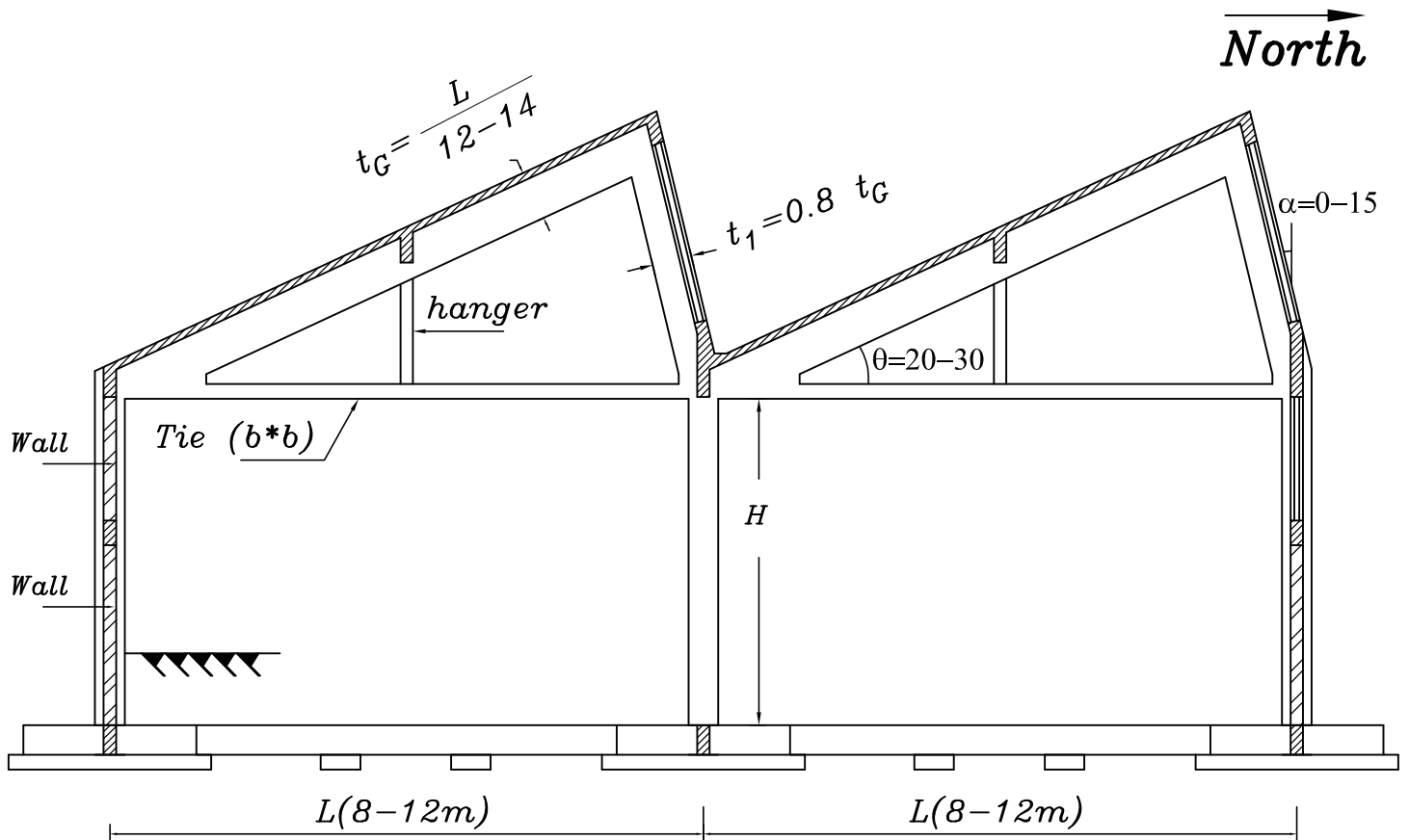
Saw Tooth Girder Type is used for Span (8-12m)

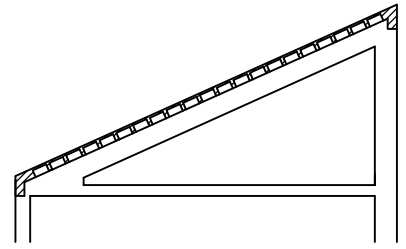## Concrete Dimensions

$$t_G = \frac{L}{12-14}$$

$$t_1 = 0.8\ t_G$$

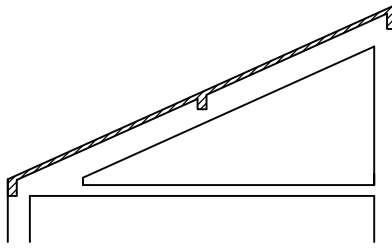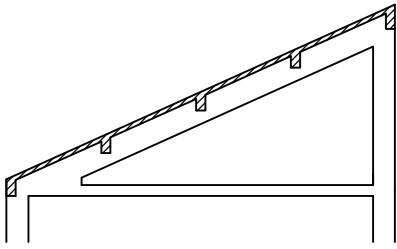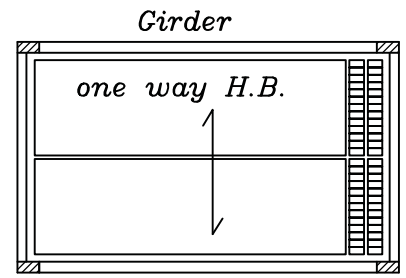$$b = \left[\begin{array}{l} 30cm \\ \\ \dfrac{Spacing}{20} \end{array} \right. \qquad \text{ايهما أكبر}$$
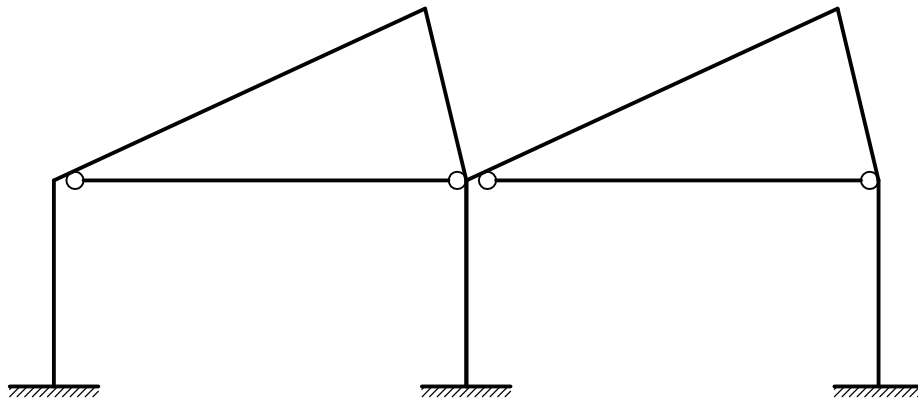
Tie (b*b) & hanger (250*250)

$$t(col) = \frac{H}{12}$$

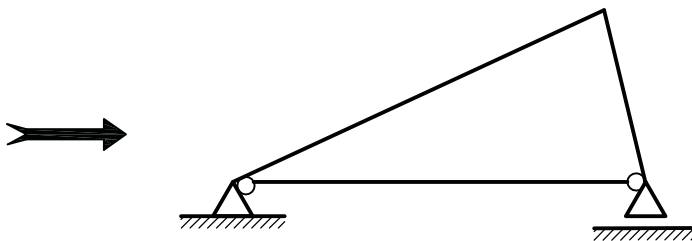# 1]Analysis of Slabs

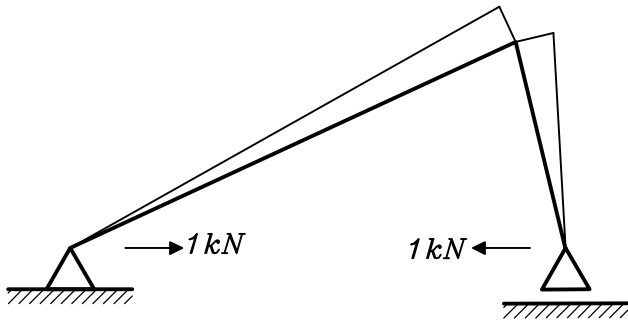Slabs may be H.B. Slab or Solid Slab.
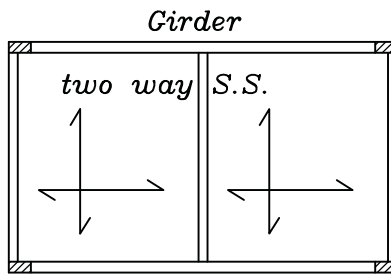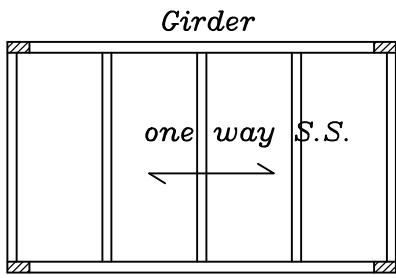
2]Analysis of girder
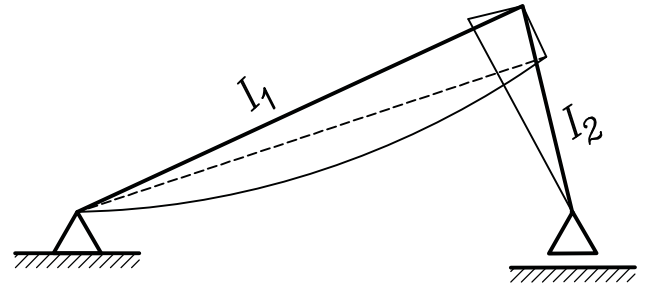

(8th)statically indeterminate

المفروض ان نحل المنشا بالكامل ولكن نظرا لصعوبة الحل سوف نهمل اتصال

الاعمدة بـ Girder ونهمل اتصال Girders ببعضها .

Using Virtual work Method (once statically indeterminate)

$$M_1 \qquad\qquad Mo$$

$$\delta_{10} = \frac{M_o\ M_1}{E_c\ I}$$

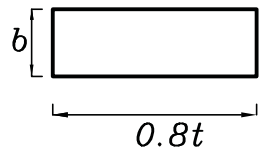$$\delta_{11} = \frac{M_1^2}{E_c\ I}$$

$$\delta_{10} + X\ \delta_{11} = 0 \qquad\qquad (Neglecting\ extension\ of\ tie)$$
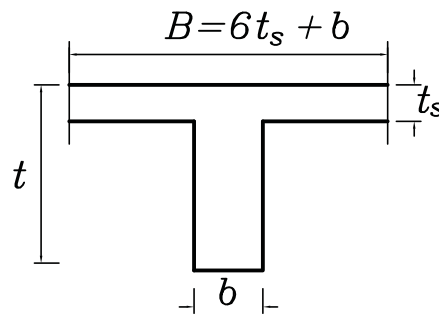
$$\delta_{10} + X\ \delta_{11} = 0$$

$$\boxed{\delta_{10} + X\ \delta_{11} = 0} \quad and\ get\ X \ \Longrightarrow \ \boxed{M_f = M_o + X\ M_1}$$
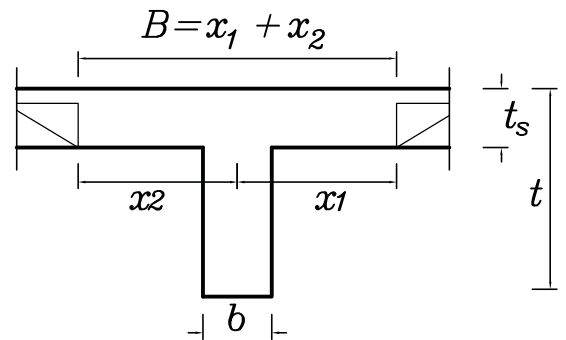
$$I_2 = \frac{b(0.8t)^3}{12}$$

$$B = 6t_s + b$$

$$I_1 = \mu B t^3$$

$$B = x_1 + x_2$$

$$I_1 = \mu B t^3$$

$$\boxed{Solid\ slab} \qquad\qquad \boxed{H.B.Slab}$$

$$M_f = M_o + X\ M_1$$

By Eng. Ezz El–Din Mostafa & Eng. Yasser M. Samir

KEY PLAN
1:200 → 1:400

Side view

spacing

spacing

(0.00)

Plan

spacing

spacing

(0.00)

$L(8-12m.)$

$L(8-12m.)$

Elevation

North

By Eng. Ezz El–Din Mostafa & Eng. Yasser M. Samir

$(0.1-0.2)As+ve$

As_{+ve}

As_{tie}

$L/3$

As_{-ve}

$(0.1-0.2)As+ve$
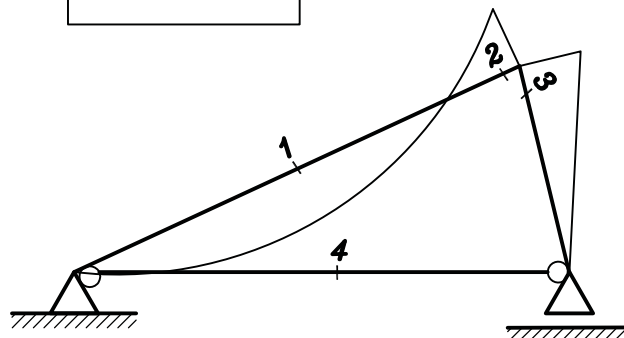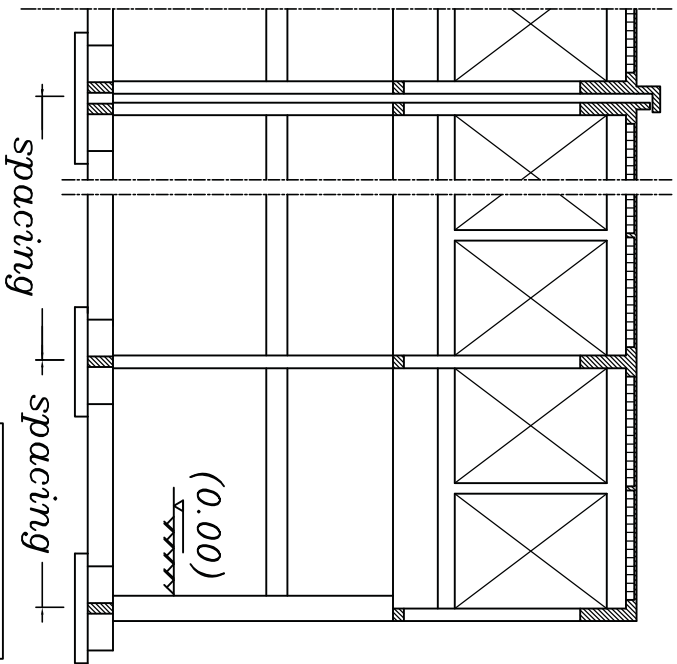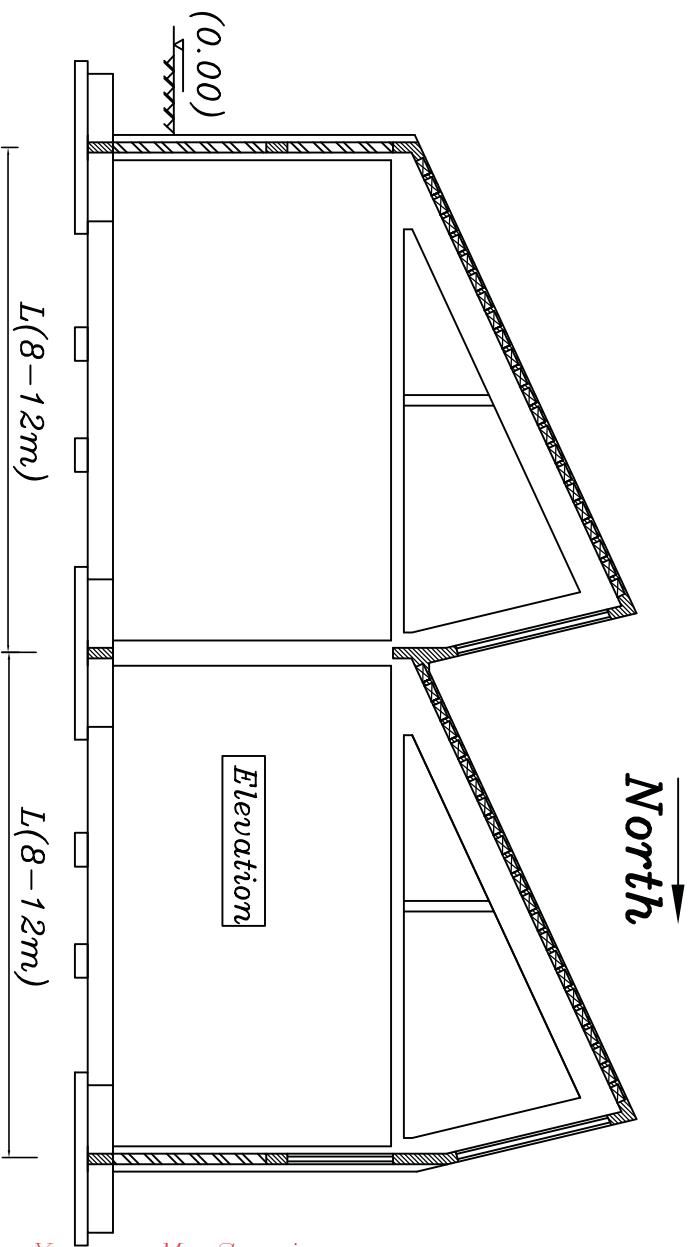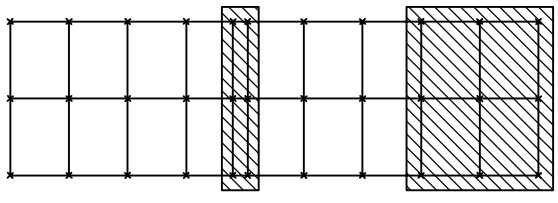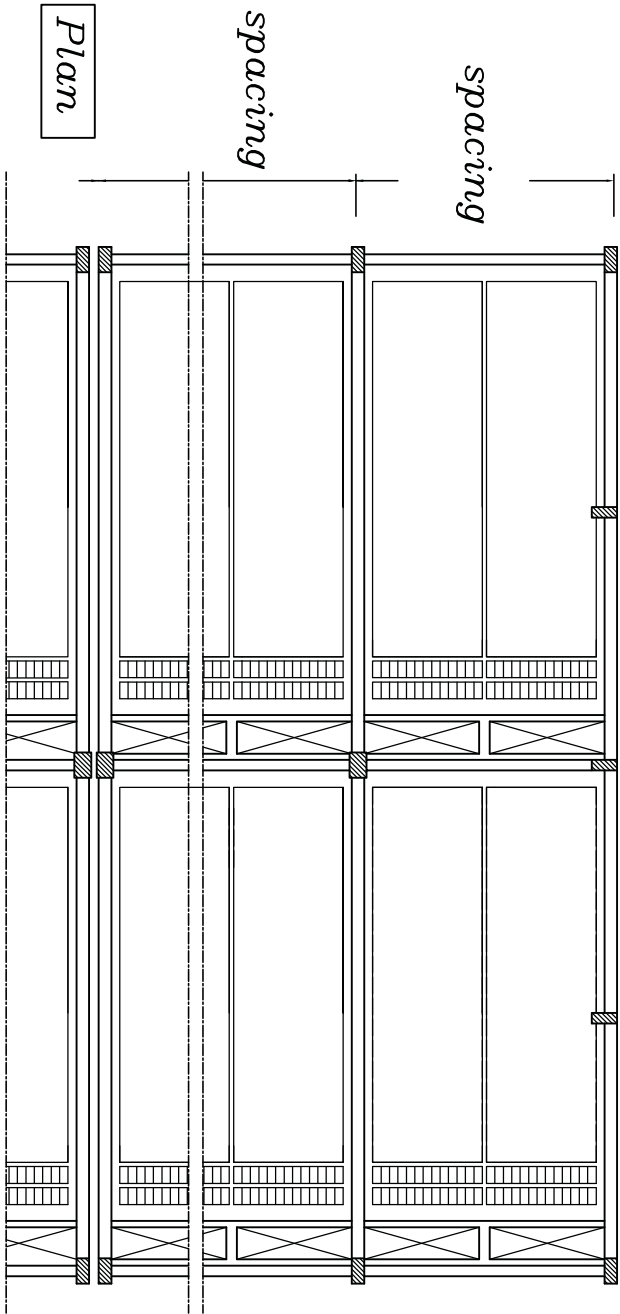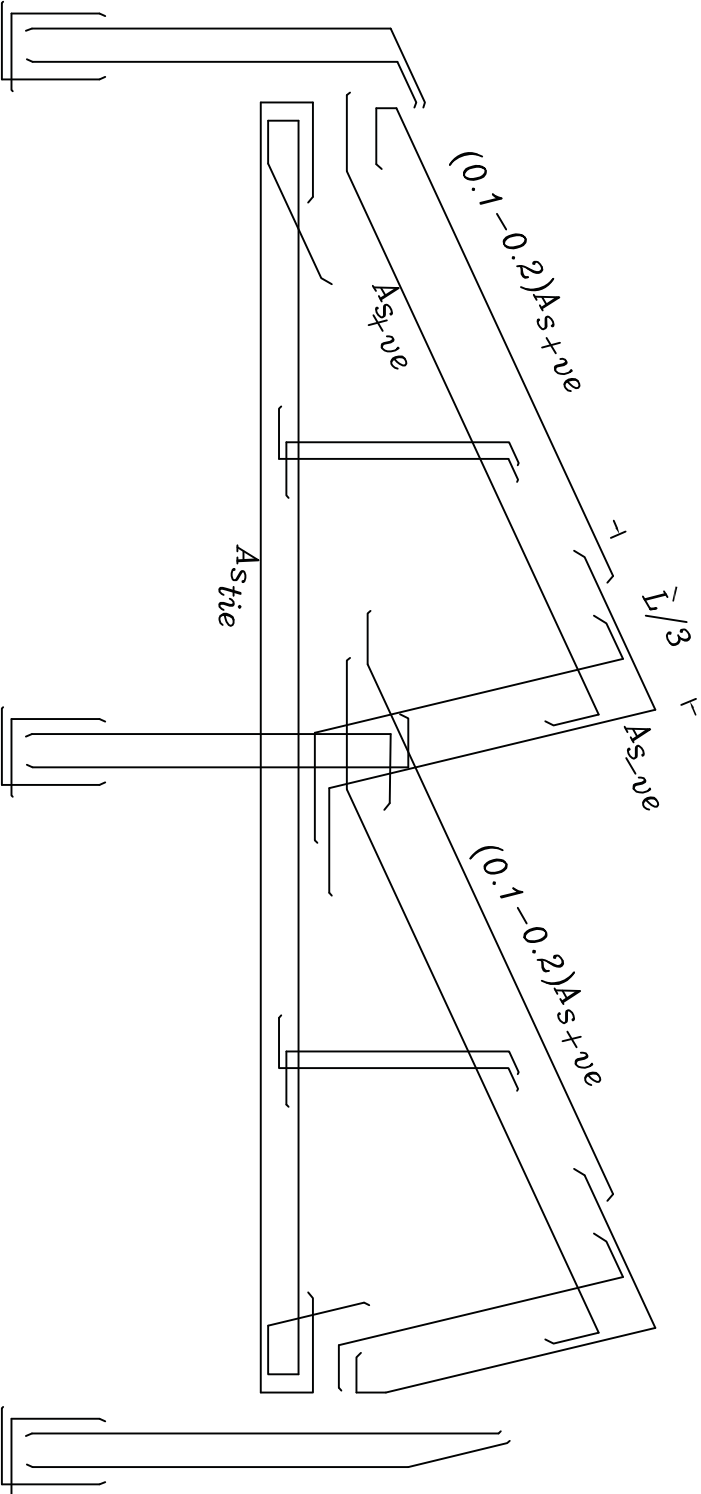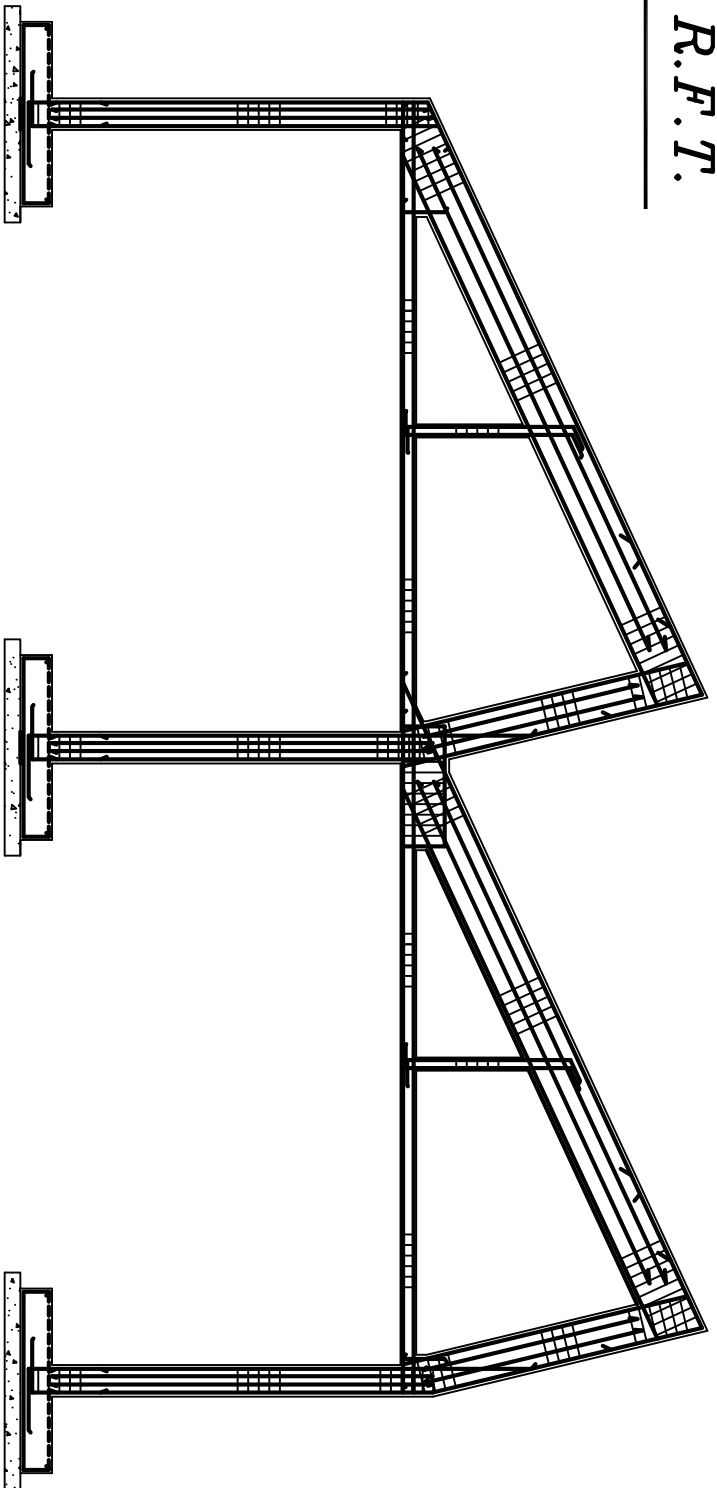
Example(3)

For the given plan and cross−section,

it is required to:

1−Choose the suitable system to cover
   this Area.

2−Design all Slabs and draw plan of Rft.

3−Design the main supporting element
   and draw details of Rft.

$$F.C.=1.4 kN/m^2 \ , L.L=1.0 \ kN/m^2$$

$$f_{cu}=25 \ N/mm^2, \quad f_y=360 \ N/mm^2$$

48m

2*12.0=24.0m

(11.00)

(6.00)

(0.00)

12.0m   12.0m

Sec.(1−1)
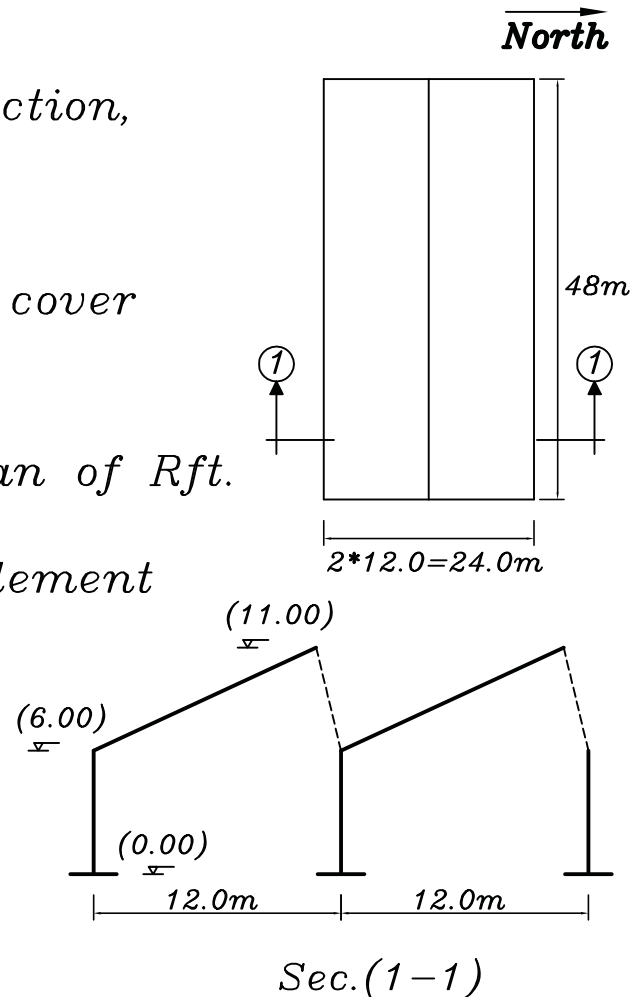
Solution

$$t \ = \frac{600}{18} =33.33 cm$$

take t=25 cm [20cm+5cm]
              check defl.

5.0m   11.90m   5.14m

θ

10.8m   1.2m

$$\theta=tan^{-1}(\frac{5.0}{10.8})=24.84$$

$$w_{su}=\frac{1.4[ts\delta_c*(e+b)+bh\delta_c+5*wt.of \ block]}{(e+b)} +1.4F.C.+1.6L.L.Cos\theta$$

$$w_{su}=\frac{1.4[0.05*25*0.5+0.1*0.2*25+5*0.16]}{0.50}+1.4*1.4+1.6*1.0*0.91$$

$$= \ 8.81 \ kN/m^2$$

$$w_{su/Rib}=0.5*8.81=4.41 kN/m`$$

4.41kN/m

6.0m   6.0m   6.0m

Side view

6.00m

6.00m

0.40

(0.00)

0.25

Plan

6.00m

6.00m

B(250*500)   B(250*500)

4φ8/m

5φ8/m

Tie(300*300)

250
200 50

2φ12/rib   2φ10/rib

2φ12/rib

2φ12/rib

B(250*500)   B(250*500)

12.00m

4φ8/m

5φ8/m

Tie(300*300)

250
200 50

2φ12/rib   2φ10/rib

2φ12/rib

2φ12/rib

12.00m

B(250*500)   B(250*500)

(−1.50)

(0.00)

(4.00)

(6.00)

(11.00)

1.00m

0.25

0.30m

0.85m

0.60

0.25

0.60

Elevation

North
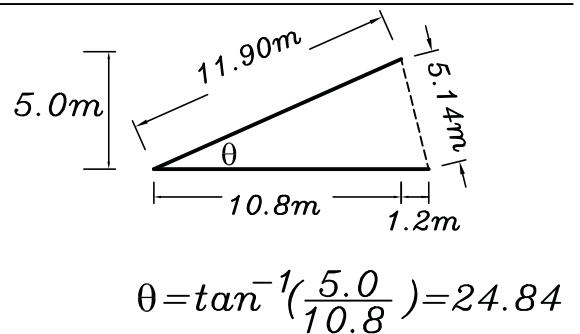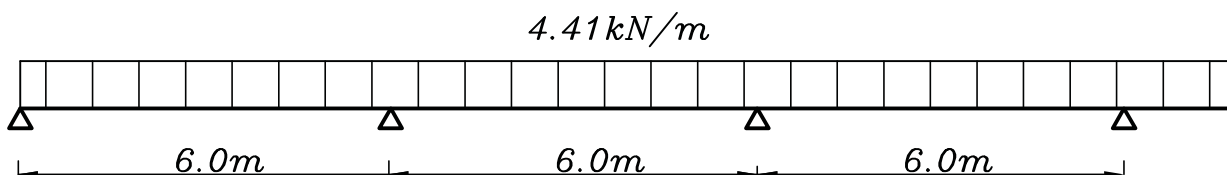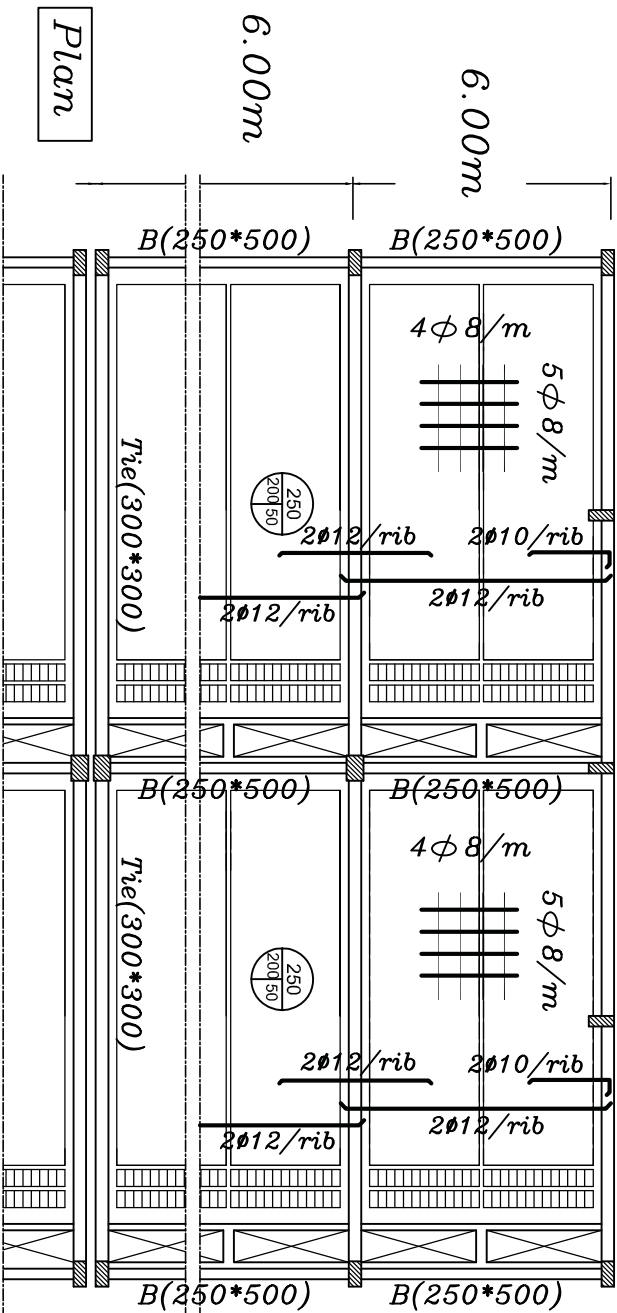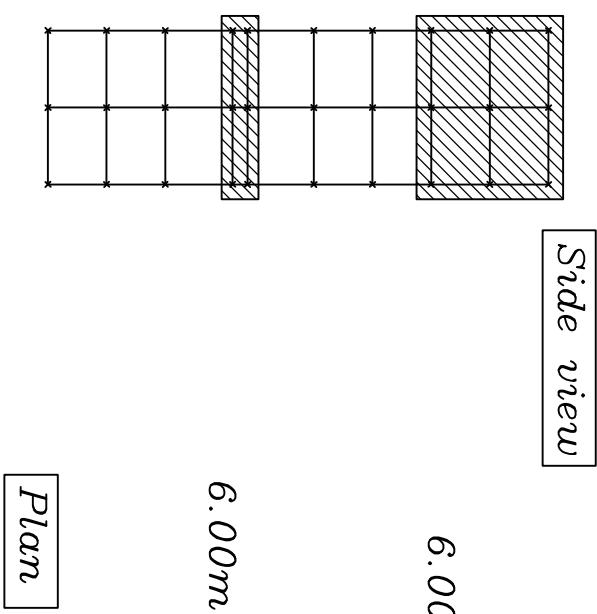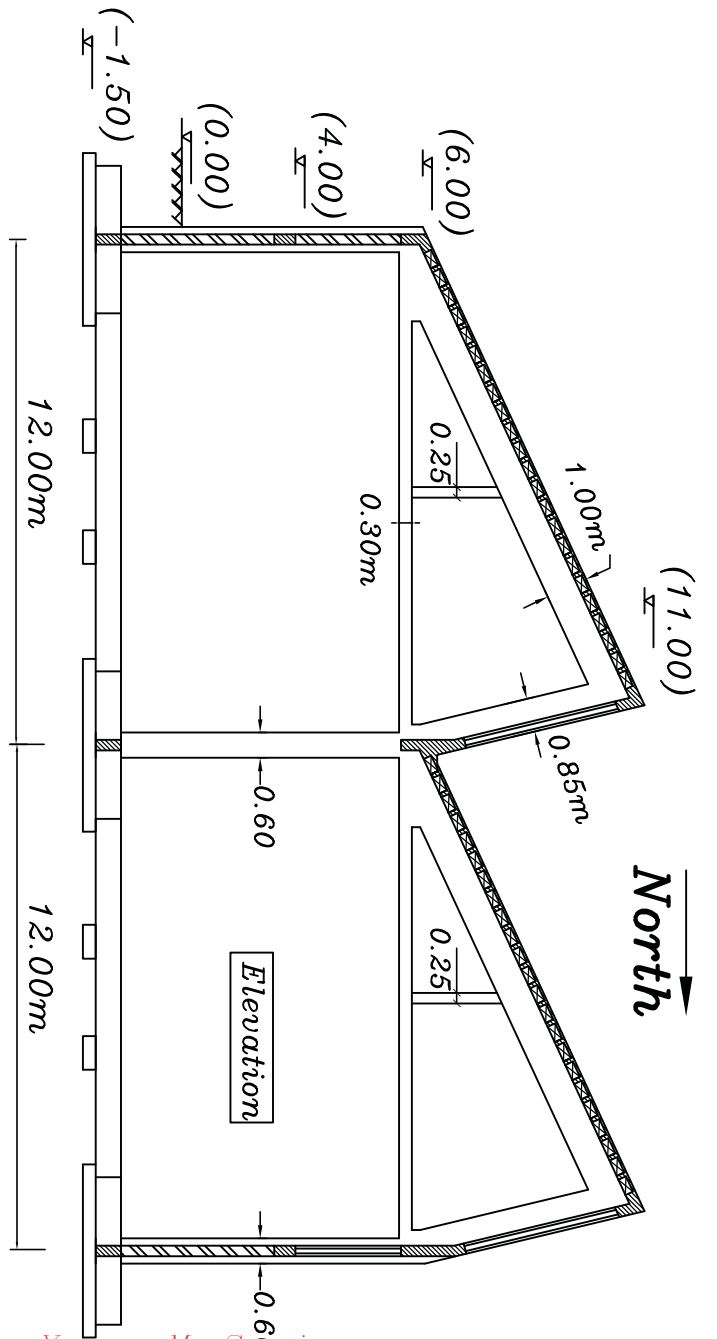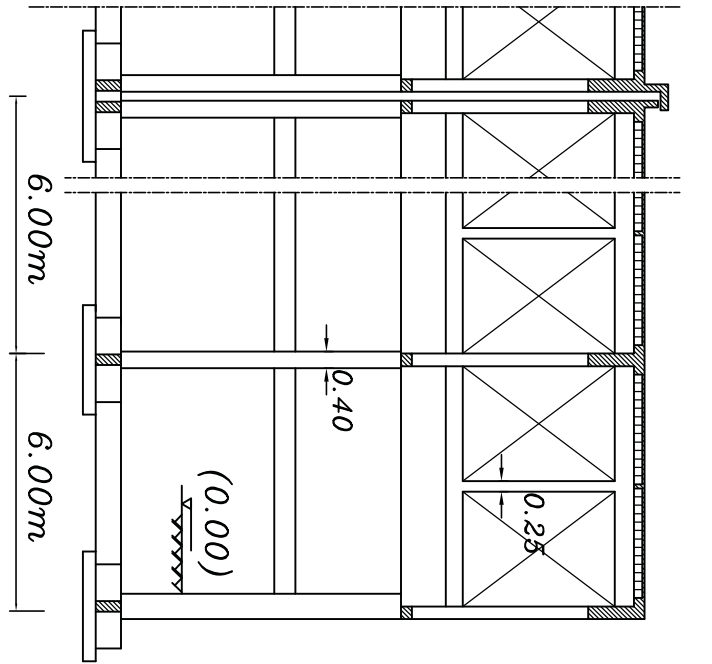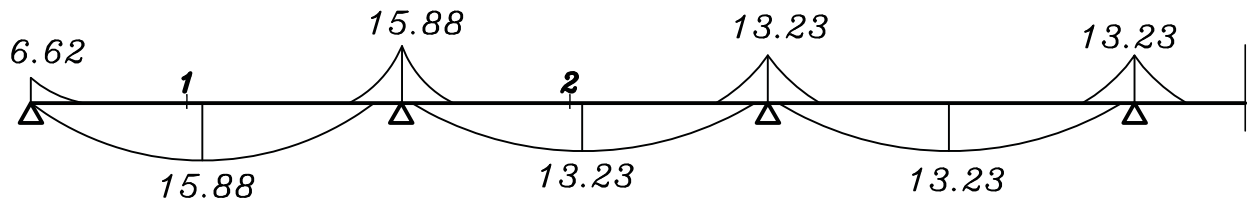
Sec. (1-1)

$$M_{des.} = M\,Cos\,\theta = 15.88*0.91 = 14.45 kN.m$$

$$220 = C_1 \sqrt{\frac{14.45*10^6}{500*25}} \qquad C_1 = 6.47 \qquad J = 0.826$$

$$A_s = \frac{14.45*10^6}{0.826*360*220} = 221 mm^2 /rib$$

$$A_s = 2\phi 12/rib$$

Sec. (2-2)

$$M_{des.} = M\,Cos\,\theta = 13.23*0.91 = 12.04 kN.m$$

$$220 = C_1 \sqrt{\frac{12.04*10^6}{500*25}} \qquad C_1 = 7.09 \qquad J = 0.826$$

$$A_s = \frac{12.04*10^6}{0.826*360*220} = 184 mm^2/rib$$

$$A_s = 2\phi 12/rib$$

Analysis of Main System

$$w_1 = o.w. + w_{su}*spacing$$

$$w_1 = 0.30*1.0*25*1.4 + 8.81*6.0$$

$$w_1 = 63.36 kN/m$$
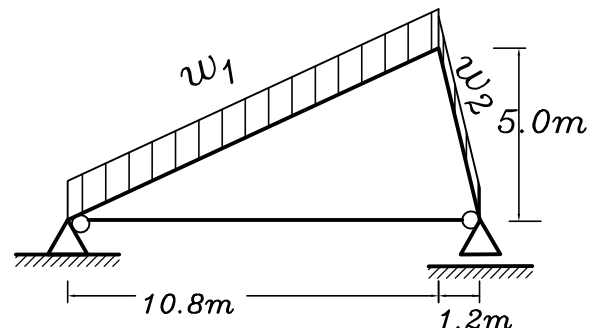
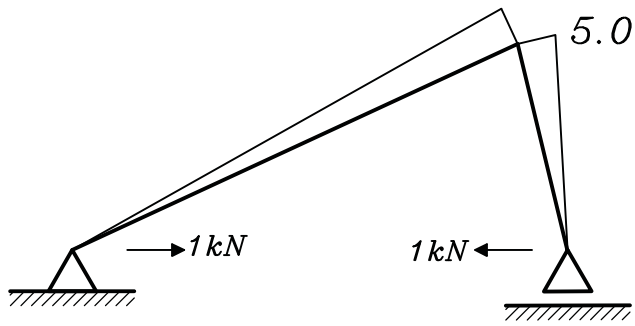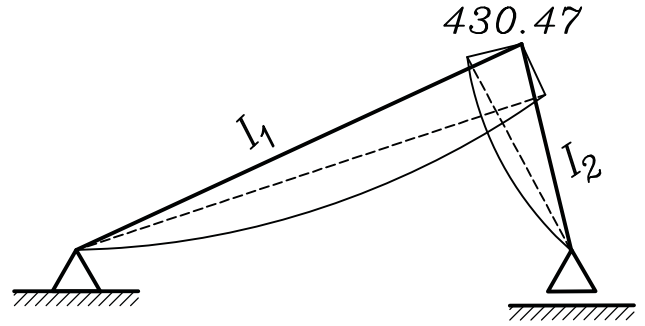$$w_2 = o.w.$$

$$w_2 = 0.30*0.8*25*1.4$$

$$w_2 = 8.40 kN/m$$

M_1

M_0

$B=0.70m$

0.25

0.35 0.35

1.00

0.30
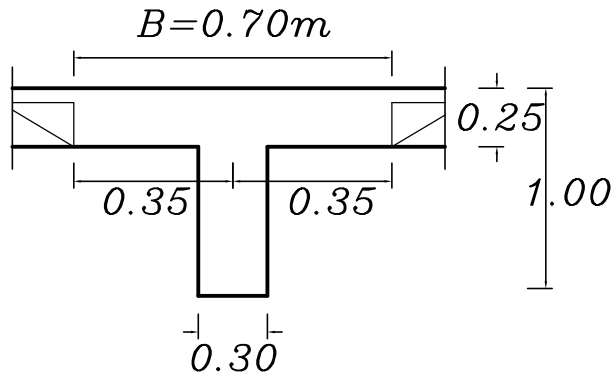
$I_1 = 515*10^{-4}*0.70*1.0^3$

$I_1 = 0.036m^4$

0.30

0.80
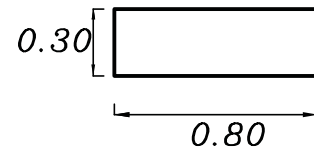
$I_2 = \dfrac{0.30*0.80^3}{12}$

$I_2 = 0.013m^4$

$$\delta_{10} = -\frac{1}{3} * \frac{11.90}{E_c\,I_1}[430.47*5.0] - \frac{2}{3}\,\frac{11.90}{E_c\,I_1}\left[\frac{63.36*11.9*10.8}{8}*2.5\right]$$

$$-\frac{1}{3} * \frac{5.14}{E_c\,I_2}[430.47*5.0] - \frac{2}{3}\,\frac{5.14}{E_c\,I_2}\left[\frac{8.4*5.14*1.20}{8}*2.5\right]$$

$$\delta_{10} = \frac{-1085869.16}{E_c}$$

$$\delta_{11} = \frac{1}{3}*\frac{11.90}{E_c\,I_1}\left[5.0^2\right] + \frac{1}{3}*\frac{5.14}{E_c\,I_2}[5^2]$$

$$\delta_{11} = \frac{6049.50}{E_c}$$

$$\delta_{10} + x\,\delta_{11} = 0$$

$$-\frac{1085869.16}{E_c} + \frac{6049.50}{E_c}\;X = 0 \qquad \boxed{X = 179.50kN}$$

$$N.F.D.$$

$$M_f = M_o + X \ M_1$$

$$B.M.D.$$

Sec(1−1)

$$\frac{N_{u.l.}}{b \ t \ f_{cu}} = \frac{179.64 * 10^3}{300 * 1000 * 25} = 0.02 < 0.04 \ (\ neglect \ N)$$

$$950 = C_1 \sqrt{\frac{784.37 * 10^6}{700 * 25}} \qquad C_1 = 4.49 \qquad J = 0.818$$
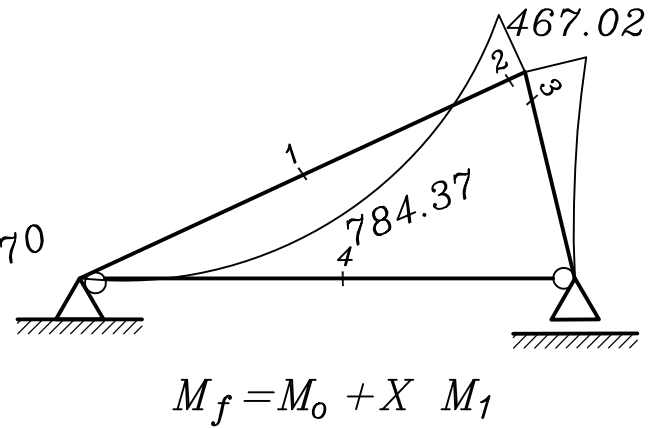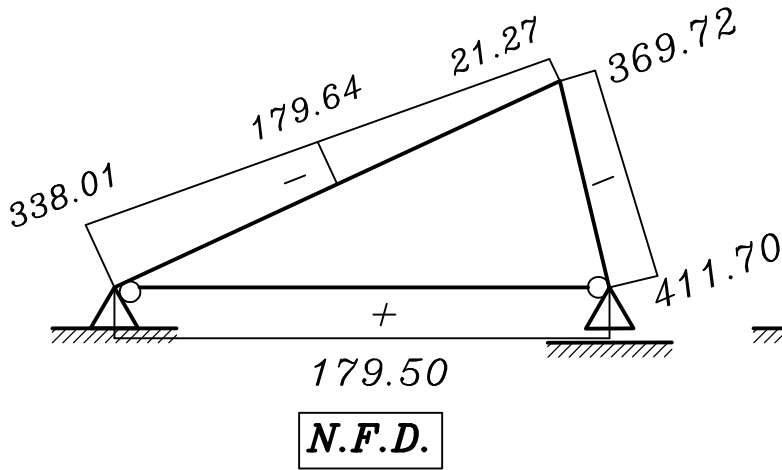
$$A_s = \frac{784.37 * 10^6}{0.818 * 950 * 360} = 2804 mm^2$$

$$A_s = 8 \ \phi 22$$

Sec(2−2)

$$950 = C_1 \sqrt{\frac{467.02 * 10^6}{300 * 25}} \qquad C_1 = 3.81 \qquad J = 0.796$$

$$A_s = \frac{467.02 * 10^6}{0.796 * 950 * 360} = 1716 mm^2$$

$$A_s = 5 \ \phi 22$$

Sec(3−3)

$$\frac{N_{u.l.}}{b \ t \ f_{cu}} = \frac{369.72 * 10^3}{300 * 800 * 25} = 0.062 > 0.04 \ (Don't \ neglect \ N)$$

$$e = \frac{M_{u.l.}}{N_{u.l.}} = \frac{467.02}{369.72} = 1.26 m$$

$$\frac{e}{t} = \frac{1.26}{0.80} = 1.58 > 0.5 \ (big \ eccentricity)$$

$$e_s = e + \frac{t}{2} - c = 1.26 + \frac{0.80}{2} - 0.05 = 1.61m$$

$$M_{us} = N_{u.l.} * e_s = 369.72 * 1.61 = 595.25 kN.m$$

$$750 = C_1 \sqrt{\frac{595.25 * 10^6}{300 * 25}} \quad C_1 = 2.66 < 2.78$$

$$assume \ t = 0.85m \quad 800 = C_1 \sqrt{\frac{595.25 * 10^6}{300 * 25}} \quad C_1 = 2.84 \& \ J = 0.72$$

$$A_s = \frac{595.25 * 10^6}{0.72 * 800 * 360} - \frac{369.72 * 10^3}{360 / 1.15} = 1672 mm^2$$

$$A_s = 5 \phi 22$$

Sec(4-4)

$$A_s = \frac{179.50 * 10^3}{360 / 1.15} = 5.73 cm^2 = 6 \phi 12$$

8]Design of Inner Col. (400*600)

$$P_{col.} = 797.16 \ kN$$

$$\delta_{b_{in}} = \frac{1.2 * 6.75}{0.60} = 13.50 \qquad \delta_{b_{out}} = \frac{1.2 * 6.25}{0.40} = 18.75$$

Column is long col. inside & outside plan

$$\delta_b = \frac{\delta_b^2 \ b}{2000} = \frac{18.75^2 * 0.40}{2000} = 0.07m$$

$$M_{add} = 797.16 * 0.07 = 56.05 kN.m$$

$$\frac{N_{u.l.}}{bt f_{cu}} = \frac{797.16 * 10^3}{400 * 600 * 25} = 0.13 \qquad \zeta = \frac{400 - 100}{400} = 0.75$$

$$\frac{M_{u.l.}}{bt^2 f_{cu}} = \frac{56.05 * 10^6}{600 * 400^2 * 25} = 0.023$$

$$\rho < 1 \ Take \ \rho = 1$$

$$A_{S \ min} = \frac{0.25 + 0.052 * 18.75}{100} * 400 * 600 = 2940 mm^2$$

$$A_s = 12 \ \phi 18$$

Details of R.F.T.

Sec.1-1

3φ16
4φ10
8φ22
0.30
1.00

Sec.2-2

3φ16
4φ10
5φ22
0.30
0.85

Sec.3-3

6φ13
0.30
0.30

Sec.4-4

12φ18
0.60
0.40

2φ10@300mm

3φ18
3φ18
8φ22
3φ16
4φ12
3φ16
5φ22
4.0m

3φ18
3φ18
6φ12
8φ22
3φ16
4φ12
3φ16
5φ22
3φ18
3φ18

By Eng. Ezz El-Din Mostafa & Eng. Yasser M. Samir